Railway Mechanical Engineer

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Use the Railway Supplymen

There are many varieties of railway supply salesmen. It is quite noticeable, however, that gradually but steadily these men are becoming less and less of the pure salesmanship type, and are more and more taking on the functions of engineering experts and practical service men. Service, not price, is the prime consideration in the eyes of the keen and far-sighted railroad buyer, and the railway supply manufacturer has awakened to a realization of this and is organizing his forces accordingly. It is indeed not out of place here to note that some of the railway supply manufacturers have helped to bring about this condition by being forced to demonstrate their devices thoroughly and then to follow them up closely in service when they were finally adopted.

The personal factor is therefore becoming of less and less importance in negotiating sales; the hard-headed railway officer is looking for real and lasting results—in fact, he must do this in order to overcome the effect of the rising costs and hold his job, as he will make a desperate fight to prevent being separated from the payroll. Many mechanical department officers realize the opportunity of securing valuable information and assistance from the representatives of the manufacturers, who are constantly traveling about the country and keeping in touch with the best practices on the most progressive roads.

For some reason, however, the railway repair shop authorities do not take this same attitude toward the representatives of machine tool and small tool manufacturers. It must frankly be admitted that Mr. Armstrong, in his communication on "Open the Shop Doors," on another page, has hit squarely on the head a weak spot in the average railway repair shop organization. Many of the representatives of the machine tool and small tool manufacturers—most of them in fact—can qualify as experts on machine tool operation and shop practices. They can bring to the attention of the railway shop management good methods and practices which are used in other lines of industry (which may be applied to advantage in railway shops) and which might otherwise never come to the attention of the railway shop authorities.

It may be argued that showing courtesies to these representatives will take valuable time from already overworked officers and foremen. If so it is time to reorganize the staff or make additions to it, for this condition indicates a tendency to get into a rut, and, like the ostrich, bury one's head in the sand. No railroad shop officer or foreman should be so busy that he cannot give time to studying how to improve the work of his shop or department.

Standard Steam Hose Coupling

Some time ago the Railroad Administration adopted as standard one type of hose coupling for steam heat lines. The matter was decided by a committee and its choice certainly is representative of the equipment used on some of the largest roads in this country. Nevertheless, there has been considerable adverse criticism of the coupling adopted and since there is a possibility that the Mechanical Section of the American Railroad Association may take up the adoption of a standard for the association, the matter should not be dismissed until the relative merits of various types are definitely established.

The hose couplings which have been most generally used are of two classes, one having a positive lock and the nipple set at an angle of 30 deg. with the face of the coupler, and the other type without the positive lock and the angle of the nipple 20 deg. The latter type was selected as the administration standard. The principal criticism of this coupling has been that the angle of the nipple is so small that it causes excessive bending of the hose when coupled, thereby setting up unnecessary stresses and often causing failures. Furthermore, it is claimed that the larger angle facilitates coupling and the positive lock increases the life of the gaskets because it keeps them tightly closed.

In favor of the non-positive lock and the 20-deg. angle it is claimed that the locking parts are easier to manipulate

and that the loss due to the hose being torn off when cars are uncoupled without separating the hose is reduced. It is doubtful whether the latter argument has much weight, because in almost every case when the hose is not uncoupled by hand it is torn off before the couplings part. That the angle of 20 degrees is rather small is shown by the fact that it is specified as the minimum in the recommended practices adopted by the Master Car Builders' Association.

The cost of steam hose is a considerable item and it should be well worth while for the railroads to keep careful records of the comparative service life secured with different types of couplings, in order that accurate data may be available in case it is desired to standardize these parts.

Mechanical Department After March 1

The mechanical department has in the past, and particularly in pre-war days, been looked upon as a more or less necessary evil—as an expense and not as an earning factor. In too many cases the heads of the mechanical department have adopted a subservient attitude and have stood for conditions that in the interests of the railroad property as a whole they should have opposed determinedly and have insisted upon being changed or corrected.

What was the result? Railroad executives waked up too late to the realization that proper maintenance and upkeep of equipment and facilities is a really vital factor in railroad operation. Roads which, like the Delaware, Lackawanna & Western, had taken a real pride in keeping their equipment in as nearly 100 per cent condition as possible, had a fairly comfortable time two or three years ago when the great majority of roads were badly up against it because of the low standard of maintenance of their equipment.

Railroad officers—many of them—deeply resented the fact that the head of the mechanical department of the Railroad Administration, an outsider so far as railroad shop practices are concerned, found it necessary to step in and show up some of their inadequate facilities and equipment. There was a real reason for it, however; it would never have been necessary in many instances if the mechanical department officers had had the courage of their convictions, and had carried the issue to the last ditch with their superior officers in pre-war days.

Mechanical department officers have been prone to criticise and blame the executive officers for not giving them the proper support in their efforts to improve the equipment and its maintenance. This is foolish. It simply indicates that the mechanical department head has lacked force or has not assembled data which would clearly demonstrate his contentions. The executive officers cannot be expected to be fully acquainted with the details of the technical departments; they have heavy responsibilities to bear in directing the properties and they rely upon their subordinates to make their needs known in such a way as fully to justify them in granting authority. It is here that mechanical department officers have fallen down.

Conditions during the past three years have forcefully demonstrated the wisdom of keeping the equipment in first-class condition and of providing adequate facilities for its care. It is not going to be so difficult for the mechanical department officer to drive home his point in the future as it has been in the past—but he must present his argument and data in such a way as to make it really effective and then keep persistently at it, in season and out of season. If he fails, the chances are that in the last analysis he is at fault in not presenting his case in the right way.

The roads go back to their owners on March 1. Congress is doing its best to get a satisfactory law enacted. It ought not to be too harshly criticised if the measure falls short of a reasonable degree of perfection. Many different and conflicting elements have been exceedingly active in trying to have their ideas adopted, and the suggestions have ranged from extreme radicalism to standpat conservatism.

Railroad officers must get this, however. Conditions as to regulation, the attitude of the public, labor and almost every other element have changed radically from those existing before the war. Railroad men must realize this, and must fairly and squarely meet the new conditions with an open mind and a determination to make good in a large way. The interests of the public, the employees, the security holders and the management are so intimately interwoven that putting on blinders and attempting to operate in the old rut will spell disaster.

You may have the idea that after March 1 you will be free of certain restraints that may have rankled in your mind. You may reason that you can drastically handle some things which are not quite as you would like to have them. You may think you can go back into the rut of some of your favorite pre-war methods and practices. May we give just a word of warning? The railroad game is going to be a bigger one than ever before. It will require big men to direct it. You may be one of those big men—but if so, you will have to study and know human nature; you will have to use your head and determinedly stand behind your guns in directing your department with a big broadminded and open-minded attitude. You must view your task in the light of a profession and not as a job.

Foundry Aids Repair Shop

Repair work on locomotives has always been delayed more or less both in back shops and roundhouses by the difficulty in getting iron and steel castings when needed. This difficulty is greater now than ever before because of the recent steel and coal strikes. Even in pre-war days, however, the process of getting castings through the usual channels of stores department and purchasing agent was exasperatingly slow from the shop foreman's point of view. Often the storekeeper at a local shop would have to get in touch with all the other storekeepers on the system before an order could be taken, and when it was finally approved and placed with a foundry the deliveries were very unsatisfactory. Every one is familiar with one result of slow material deliveries—namely, the robbing of various parts from one locomotive to complete another, a costly practice which should not be tolerated. Locomotives must not be delayed in the shop, however, and there is a serious temptation for the men responsible for output to rob the desired part from a locomotive due out some time later. Consider, for example, a locomotive that comes to the shop with a cracked front deck casting not mentioned on the work report. If the casting is cracked too badly to be welded and there is none in stock, there will be a serious delay in getting the locomotive back into service, with the attendant loss of revenue.

One way to avoid the above difficulty lies in the establishment of a foundry in conjunction with the repair shop. Experience has shown that where conditions are favorable it is possible to operate not only a grey iron but also a steel foundry to furnish all the smaller castings, such as driving boxes, cylinder heads, front frames and deck castings, needed. Good quality grey iron castings are now being made in railway foundries, and the relatively greater difficulty in making steel castings has been overcome, as shown by the satisfactory results of rigid physical and chemical tests. With suitable foundry facilities no locomotive would be held up for machine parts, since they could be cast in the local foundry in less than 24 hours. The unit cost of the castings thus made would be high, due to their light weight, and the saving effected has proved in an actual case sufficient to pay all carrying charges on the investment involved.

Not only is it possible to make standard castings promptly, but a pattern of any special part can be made quickly and be cast, whereas the old method of ordering from an outside foundry would require several weeks. There is danger of overdoing a good thing in the matter of special castings, and none should be made unless authorized by the master mechanic. A careful check should also be made of standard castings and none delivered to the shopmen without orders signed by their foremen. Taken altogether, the great convenience of having castings when needed, the reduction in the amount of stock carried on hand and the resulting economy, make the foundry a most valuable adjunct to a large railway repair shop.

Selecting the Type of Locomotive

It is essential to the proper development of the railroads—in the eastern section of the United States particularly—that mechanical engineers and operating officers give careful consideration to the type of locomotives which they expect to build in the immediate future. It is quite probable, indeed imperative, that there be built a great amount of motive power in the next several years, and with the traffic becoming more and more dense the problem becomes one not only of adequate volume of motive power, but also of providing this power in the minimum number of units consistent with a mobile organization.

Just as it is necessary to have a tool of adequate capacity in the shop in order to effect economical production, so also is it necessary to have motive power in units of adequate size economically to perform the service required of them. It is an indisputable fact that 120,000 lb. of tractive power may be more economically maintained and operated if contained in only two units each having a tractive effort of 60,000 lb., than would be the case if the same amount of power were distributed in three units of 40,000 lb. each. The saving in fuel and cost of repairs would be large enough to make such a course desirable, but when, in addition to these savings, the savings in wages of engine crews is considered it is obvious that the fewer units in which the power is contained, the lower the cost per pound of tractive effort will be.

This, however, presents a problem involving track conditions and terminal and transfer point requirements. It will require the best engineering brains in the railroad field to determine the most suitable type of locomotive for a specific service and then to design it to meet the conditions under which it will operate. The successful operation of some heavy switching locomotives recently built for use on one of the larger southern railroads is evidence of the great possibilities lying in this direction. Economy and utility demand that this phase of locomotive design be given the most careful attention.

NEW BOOKS

Complete Practical Machinist. By Joshua Rose, M. E. 547 pages, 5 in. by 7¾ in., illustrated, bound in cloth. Published by Henry Carey Baird & Co., Inc., 2 West Forty-fifth street, New York.

This book is the twentieth edition of the work and is greatly enlarged in scope. It treats of practical machine shop methods in the language of the shop man and gives in concise form many explanations, with suitable illustrations, of the uses of the tools of the shop. As in previous editions the book gives practical instructions in the use of metal working tools and tells precisely how the various operations should be performed. In addition to a description of cutting tools and their uses there are several chapters on the use of machine tools and their attachments. The very important subject of cutting speed and feed is treated in a comprehensive manner which should prove to be of great value to the machinist. Other subjects which are presented in a practical form are boring tools for lathe work, boring bars, screw cutting tools, twist drills, taps and dies, tool steel, vise work tools and slotting tools. The turning of eccentrics, drilling in the lathe, fitting connecting rods, milling machines and tools, grindstones and tool grinding, the setting of slide valves and other subjects of interest to the practical machine shop man are discussed in a chapter devoted to each subject. The book should prove a valuable addition to the library of the shop man.

Applied Science for Metal-Workers. By W. H. Dooley, 467 pages, 5¼ in. by 7½ in., illustrated, bound in cloth. Published by the Ronald Press, New York.

This book is similar in character to Applied Scence for Wood-Workers by the same author, and covers in the same way the general principles of science common to all industries. In addition to this it presents in an easily understood form practical applications of the principles underlying the metal workers' trades. It contains not only a presentation of the data necessary to equip the student for the intelligent study of industrial science, but also deals in a practical way with modern foundry practice, the making of wrought iron and steel, machine shop practice, sheet metals, structural steel and other subjects relating to the metal working trades. A series of questions and problems on each subject gives the student a very thorough examination and illustrates in a lucid manner the purpose of the work done as well as the methods used in performing it.

Proceedings of the Traveling Engineers' Association. Edited by W. O. Thompson, secretary. 366 pages, 5¾ in. by 8½ in., illustrated, bound in leather. Published by the association.

This volume contains the proceedings of the twenty-seventh annual convention of the association held at Chicago, Ill., September, 16-19, 1919. The address of the retiring president, H. F. Henson, is given in full. The reports of the secretary and the treasurer for the year ending July 31, 1919, are included and show the affairs of the association to be in properous condition. Committee reports and individual papers on various topics of interest to engineers and railway men in general are given in full with the discussion by the members. Among the subjects considered are: Methods for handling air brakes; adjusting tonnage of slow freight trains; advantages of the application of stokers to modern locomotives; locomotive efficiency and fuel economy; and caring for locomotives at terminals.

This volume also contains the obituaries of those members of the association who passed on during the year. Among these are Dr. Angus Sinclair and Dr. Walter V. Turner. The sketches of the careers of these two justly honored members of the Traveling Engineers' Association, together with an excellent likeness of each, will give this issue of the proceedings of the association an especial value to the members at large, as well as to a host of men in other walks of life.

Metric Standardization Favored.—Out of 58,226 petitions relating to exclusive use of metric weights and measures in the United States, now in the keeping of the Bureau of Standards, Department of Commerce, 57,800 petitions or 99.27 per cent favor this progress and only 426, or less than 1 per cent oppose it. This unqualified endorsement of metric standards for this country is brought out in the analysis just completed at Washington by representatives of the World Trade Club, of petitions sent to President Wilson and America's national legislators by prominent persons and powerful commercial, manufacturing, civic and fraternal organizations of the United States. Some of these petitions represent unanimous resolutions passed at conventions of organizations with thousands of members.—*Domestic Engineering.*

COMMUNICATIONS

OPEN THE SHOP DOORS

NEW YORK CITY.

TO THE EDITOR:

Did you ever stop to consider what this old world would be if we had not interchanged ideas in the past? What degree of progress would have ensued if everyone had had to make original discoveries of all that he utilized in his daily task? How much of that which you accomplish is due to knowledge acquired from others, from practices developed by others? Did you ever introspectively contemplate how your life, your occupation, and your success is dependent upon the dissemination of acquired knowledge?

Realizing these truths and the interdependence of mankind and industry, do you fully appreciate and utilize the avenues open to you for acquiring a small portion of the available knowledge and thus bettering your operating conditions. These avenues are: (1) Technical literature; (2) Technical journals; (3) Demonstrators, salesmen and service men; and (4) Personal observation.

Technical Literature. The most powerful agency today is the printed word. Records of past accomplishments can thus be used as stepping stones for better conditions and improved operation. Here are to be found the fundamental principles underlying all activities, as well as specific applications and a wealth of recorded knowledge.

Technical Journals. The technical journal supplies this same need but with a closer relationship to the specific task. Through it you are kept in touch with developments in advance of their availability in book form. Its many eyes and ears serve to keep you in close contact with the progress from which you can select that which can be most advantageously used without the necessity of saving to personally develop it yourself. Its advertising serves to bring to your door the wares of the world which can be used to increase efficiency, decrease costs and through better operation insure the very existence of your industry.

Demonstrators, Salesmen and Service Men. The developed efficiency of the locomotive of today and its parts such as the stoker, improved trucks, safety valves, automatic fire doors, superheaters, brick arches and numerous minor details has been brought about by the continued untiring efforts of the supply men. True the railroad man has done his share, but if it had not been for the supply man, his service and his energy, would the locomotive be what it is today?

While the relations with the so-called railroad supply man have been more or less close, it has not been so with the machine tool salesman and demonstrators. To them the average railroad shop has a closed door. The machine tool and small tool design manufacture and operation has developed much during the period that the railroads have marked time. Open the doors to the demonstrators, salesmen and service men. Don't turn them loose unguided in your shops, but consult them, let them aid you and you will be surprised at the knowledge acquired and the improvement effected through such contact.

Many concerns stand ready without expense to aid you in bettering your operation through demonstrators, but find it impossible to pass your closed doors. Don't, through fear of the exception who misuses the privilege of entering your shop, reject the good to be derived from the many who will amply repay you for the courtesy. Learn whether you are getting the best operation, whether your tools give the best and cheapest results. Don't blindfold your shop eyes by disregarding this service by the machine tool and small tool manufacturer.

Personal Observation. Go yourself to see what the other fellow is doing, but if you can't go send your subordinates. Go with the spirit of desire to learn and acquire, not to see in what you excel the other fellow. Human nature is such that it is easier to commend than to criticize. Observe with the intention of criticizing your own conditions, improving them and availing yourself of that which is done better elsewhere. Constructive criticism is a force; self complacent satisfaction is stagnation. If you would advance you must utilize the forces at your command and those of most value are the qualities of an open receptive mind and an open door. Open the doors of your shop to the agencies which instill competition and progress, and to the knowledge of others and the results will fully repay you.

G. W. ARMSTRONG.

REVERSING BRAKE SHOES A BAD PRACTICE

CHICAGO, ILL.

TO THE EDITOR:

In the December issue of your publication there appeared an article on brake shoe service, under the caption "Watch the Brake Shoes," which treats of a method of getting the most wear from the brake shoe and one that has been in practice for a number of years. You will, perhaps, be interested in my ideas on this subject and I should like to have them considered as a reply to the article mentioned:

The simple fact that there are still so many unevenly worn brake shoes on our cars today and still more evidence of them in our scrap piles would indicate that something is wrong with the practice of reversing worn brake shoes.

The practice itself has many objections. A brake shoe badly worn wedge-shape transmits torsional strain to the brake beam structure for which it was *not* designed. A turned brake shoe with the thick end at the top must have excessive slack in order to prevent its dragging too heavily on the wheel tread when brakes are released, which is very undesirable. With this slack in the brake rigging, the lower part of the shoe, which is thin, stands away from the wheel several inches. When the brakes are applied, the top of the shoe being in contact with the tread of the wheel, acts as a pivot and allows the lower thin end to slap against the wheel, often breaking the shoe. The position of a turned shoe with the thick portion at the top increases the pressure or drag on the wheels creating a still more severe retarding action on the wheels when cars are in motion and brakes released.

In the common method of applying brake beams the suspension is such that the forward end, plus the weight of the levers and rods, forces the top of the brake shoe against the wheel with a pressure of approximately 16 lb. per shoe. The natural result is a shoe worn thin at the top. If there is excessive slack in the rigging the top point of the shoe is worn. If the proper clearance only is provided, the shoe will wear gradually, resulting in the wedge shape so commonly seen.

Reversing brake shoes is not only a bad practice, which is eliminated by the use of a proper brake beam support. but the labor cost is greater than it should be. It is especially desirable to eliminate labor which is expended on bad practice. This class of labor that changes brake shoes is just as likely as not to change brake shoes that have already been changed. Duplicating labor in a bad practice is still worse.

In summing up the matter, isn't it a question of correcting the cause to get the proper effect?

By properly supporting the brake beam, we compensate for the force that is pressing the top of the shoe against the wheel, so that when the cars are in motion and the brakes released the shoes will not drag against the wheel. This will eliminate the unevenly worn brake shoe and do away with the necessity of careful watching and turning of the brake shoe.

C. HAINES WILLIAMS

Vice-President, Chicago Railway Equipment Company

LOCOMOTIVE OPERATION AND FUEL ECONOMY*

Quality of Fuel an Important Factor; Organization and Co-operation Effective in Preventing Waste

BY ROBERT COLLETT

Assistant Manager Fuel Conservation Section, Division of Operation

FUEL costs are a means for measuring progress. Good locomotive performance and good fuel performance are synonyms with good railroading, and it takes pretty nearly everybody on the railroad to bring it about. Three things are essential to real results—good fuel, good locomotives and real co-operation.

It is of interest to note the growth of the fuel problem. For the year 1912 the railroad fuel bill in the United States, for moving trains alone, was $224,516,000. In 1918 it was $495,612,000. Adding 12 per cent for fuel used for miscellaneous purposes, gives a total for 1912 of $251,458,000, and for 1918 of $555,085,000, an increase of 121 per cent. For 16 of the principal roads entering St. Louis the fuel bill for the year 1912, estimating 12 per cent of the total fuel as being used for miscellaneous purposes, was $58,451,000; in 1918, $149,602,000, an increase of 155 per cent.

In that period the number of locomotives in service on these 16 roads increased 9.9 per cent. The average tractive power of locomotives increased 7 per cent. The total freight business handled or gross ton miles increased 24 per cent and passenger car miles increased 4.5 per cent. In 1912 the number of superheater engines on these roads was 6 per cent of the total engines in service. In 1918 this had increased to 30 per cent of the total.

The majority of roads did not keep ton mile statistics in 1912, but for a few of the principal roads that did and which may be considered as an average, the unit basis of consumption decreased in the period of 1918 over 1912 in freight service 8½ per cent per thousand gross ton miles, and in passenger service 8 per cent in pounds burned per passenger car mile, this notwithstanding the fact that the quality of the coal had deteriorated and that the very severe winter in 1918 was also a factor. It has been estimated for the year 1917 and for a considerable portion of 1918 the ash content and impurities in railroad fuel used in the United States increased at least 5 per cent. This is equivalent to 8,400,000 tons, or to 210,000 cars of 40 tons capacity loaded with incombustible material. This will serve to emphasize, if such emphasis were necessary, that although a greater efficiency was obtained on a unit basis the need still exists for securing the greatest efficiency from each locomotive in service and from each ton of coal purchased. It shows the greater penalty being paid for engine failures or poor performance, since the annual cost of fuel on the roads referred to increased from $3,200 per locomotive in 1912 to $7,450 in 1918.

The Fuel Situation

Prior to the beginning of the war the fuel question in many parts of the country could scarcely be considered a problem. Coal of the very best quality was so cheap that in some cases on busy coal-producing roads if a car were derailed it was cheaper to turn the contents down the bank than to salvage it. Slack and mill coal sold as low as 40 to 50 cents per ton and was sometimes dumped on the right of way for want of a market. Little wonder, then, that appeals to the enginemen and others for small savings were not always seriously considered. Sixteen million tons a year was the maximum exported, the larger part went to Canada. We are now told that some eighty million tons annually are required for export and that Europe's reconstruction plan depends to a great extent on our ability to furnish fuel.

A few years ago Pocahontas and Westmoreland coal sold as low as $1.25 per ton at the mines, or around $2.25 at the seaboard; it is now selling as high as $7 per ton at the seaboard for export and for ship bunkers. The ocean-going freight rate is from $25 to $30 per ton, and American coal recently bought by the city of Vienna at the present rate of exchange represents a cost to them of $50 per ton. Even though the present miners' strike had not arisen, all indications are that with an average winter it is likely that the domestic, to say nothing of the foreign, requirements would not be met. The closing down of so-called non-essentials brings much discomfort and loss to the persons thrown out of employment. At the present rate of consumption each day there is from one million to a million and a quarter tons less coal in the United States. This means that the source of supply for railroad use is rapidly changing and that we must adapt ourselves to using the lower grades of fuel in order that the higher priced eastern coal may be available for ship bunkers and for export. Entirely apart, therefore, from a money-saving standpoint, the absolute need of every reasonable effort in the conservation of our fuel supply is apparent.

What Has Been and Is Being Done

Fuel is the second largest item of expense to the railroads. It ranks next to wages, and in the cost of train operation fuel costs not infrequently exceed that of wages. Fuel economy in railroad service has always received considerable attention, and fuel performance records are now compiled on all roads under federal control. The result is reflected in the saving shown on all roads in the nine months' period, January to September, 1919, compared with same period 1918, of $21,863,990 in passenger and freight service, exclusive of company haul. On a basis of pounds used per switch locomotive mile there has not been a corresponding saving, due to the fact that with the reduced number of locomotives there has been a greater amount of work performed by each locomotive; compiled, however, on the volume of business handled or ton mile basis, switch engine saving amounts to $2,716,500, bringing the total saving for the nine months' period to $24,663,000. Very large economies have also been effected in power plants.

Fuel conservation has been ably supported, but while much has been accomplished much more remains to be done. Officers on individual railroads who have made ample study of the situation say that the surface has just been scratched.

Where Waste Occurs

At a meeting of representatives from each railroad in the Eastern region the question as to the causes of the greatest avoidable waste was asked. The substance of these replies were: Quality of fuel, locomotive conditions, delays at terminal and on the line, locomotive management, and the lack of the co-operation of all departments.

Quality of Fuel

Local environment usually decides the grade of fuel the railroad must use, but the most objectionable thing is to be continually changing the grades of fuel or the preparation of it. Coal containing more heat units or requiring different

*From a paper presented before the St. Louis Railway Club.

methods of firing or drafting of the locomotive from that ordinarily used, although giving excellent results on one division or railroad, may almost tie up another from steam failures. Buying for price or even chemical analysis on the open market should be avoided, if possible. The locomotive cannot be adjusted or the enginemen become accustomed to the change over night, and it is useless to expect it. Therefore, since the railroad must have its supply of fuel in order to move other business, less coal and fewer cars to handle it will be used if an adequate supply of uniform grade is maintained.

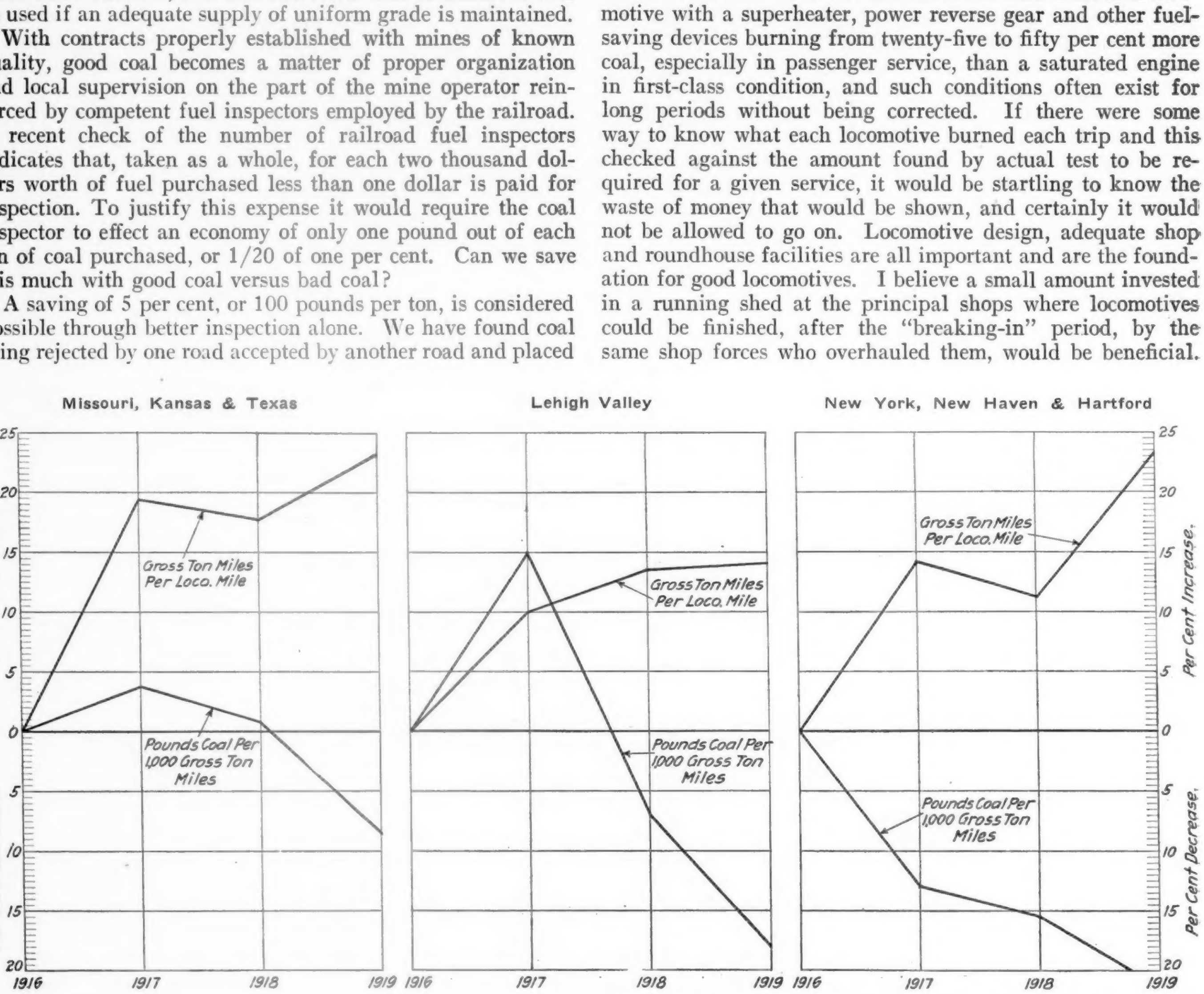
With contracts properly established with mines of known quality, good coal becomes a matter of proper organization and local supervision on the part of the mine operator reinforced by competent fuel inspectors employed by the railroad. A recent check of the number of railroad fuel inspectors indicates that, taken as a whole, for each two thousand dollars worth of fuel purchased less than one dollar is paid for inspection. To justify this expense it would require the coal inspector to effect an economy of only one pound out of each ton of coal purchased, or 1/20 of one per cent. Can we save this much with good coal versus bad coal?

A saving of 5 per cent, or 100 pounds per ton, is considered possible through better inspection alone. We have found coal being rejected by one road accepted by another road and placed on the first road's locomotives at joint terminals. At one point 210 tons per day being loaded for commercial purposes required the services of nine slate pickers to remove impurities; but 900 tons per day from an identical seam were going for railroad use, with no slate pickers on the cars and all the impurities being loaded. Too much emphasis cannot be put on securing the best preparation the mine can produce and on intelligent distribution of the railroad fuel. Where possible, coal should be billed from the mines to the point where it is to be used and so carded that proper grades and sizes will be delivered; otherwise a car of coal is simply a car of coal to the yard men, regardless of kind of coal or equipment. The grade of fuel is the foundation of fuel economy, and mining conditions and miners' contracts have so changed in the past few years that it is just as necessary to build up the fuel inspection and distribution as it was to provide better inspection for pooled than for regularly assigned locomotives.

Recently a few regional fuel inspectors have been put on whose business will be to co-ordinate the ideas and efforts of the present railroad inspection force. In many cases the inspectors for a certain railroad can inspect for another road in the same section that does not maintain inspectors.

Locomotive Conditions

Waste from improper locomotive conditions includes, of course, special appliances which are put on either to save coal or to save work. It is not uncommon to find a modern locomotive with a superheater, power reverse gear and other fuel-saving devices burning from twenty-five to fifty per cent more coal, especially in passenger service, than a saturated engine in first-class condition, and such conditions often exist for long periods without being corrected. If there were some way to know what each locomotive burned each trip and this checked against the amount found by actual test to be required for a given service, it would be startling to know the waste of money that would be shown, and certainly it would not be allowed to go on. Locomotive design, adequate shop and roundhouse facilities are all important and are the foundation for good locomotives. I believe a small amount invested in a running shed at the principal shops where locomotives could be finished, after the "breaking-in" period, by the same shop forces who overhauled them, would be beneficial.



Relation of Coal Consumption to Weight of Trains in Freight Service

A number of roads are getting excellent results from having traveling engineers ride locomotives the first trip from the shop. The defects are taken care of by the same force that overhauled the locomotive, and it is, of course, educational to them—the defects found being discussed in the shop superintendent's staff meeting. Locomotive failure records of roads using the same basis of comparison vary widely, from as low as five and six thousand miles per failure to as high as thirty thousand miles per failure. Aside from correct design, this is chiefly due to lack of attention to details.

We lack education in the care and handling of stokers and other appliances. In the matter of new types of power, European practices are, I believe, better than ours. They get one locomotive and test it out thoroughly, then build the others to that. We buy a large number of locomotives at one time, put them in the heaviest traffic territory, and the man who has to handle them is entirely unfamiliar with the types and, many times, the appliances.

Feed Water

Remarkable results have been accomplished on some roads in the improvement of feed water. On one road having something like 600 locomotives, where flues were formerly changed once in six months, fireboxes removed in from 12 to 18 months, the flues now run the full three-year period and the life of fireboxes increased correspondingly. This has been brought about by intelligent treatment of feed water, although the roads run through, for the most part, a territory which may be considered as bad-water districts from a scale standpoint. Where cost is not prohibitive and better water could be obtained, the source of supply has been changed. Where this was not possible, water treatment has been applied. The organization consists of a chief chemist, with one inspector for about 25 stations, or a total of 5 men for the entire railroad. On this road locomotive failures due to leaking flues were:

Before water treatment	1911—931 flue failures
After water treatment (not complete for all divisions)	1916— 34 flue failures
On the largest division (really two divisions)	1911—468 flue failures
	1916— 1 flue failure

A record of staybolt renewals kept for 1916 showed:

One division without treatment	1916—196 per engine
Another division with treatment	1916—9.5 per engine

Fire box renewals were as follows:

	Fire boxes applied	Fire boxes per 100 locos.
Before treatment	83	14.1
After treatment	10	1.6

The cost of locomotive failures is difficult to estimate, but it has been stated on good authority that under existing conditions on a busy trunk line railroad $100 per failure may be accepted as conservative.

Many tests have been made showing the fuel loss due to scale, but this represents the expense only partially. Some roads are renewing fireboxes at periods of 10 to 12 months and changing flues even more often.

Heating or lubricating failures waste fuel. Some roads have considerable trouble on this account, although the locomotives are liberally supplied with water pipes. On other roads operating the hardest service and certain trains not making stops over 150 to 180-mile divisions, with not a single locomotive on the railroad equipped with water, heating failures are almost unknown. This has been brought about by specializing at the shops and putting it up to the terminals.

Cylinder and Valve Blows

Some roads run cylinder packing on superheater engines six months or more, and often from shopping to shopping; others make renewals on an average of not more than eight or ten thousand miles.

It has been said that a locomotive new from the builders, having made its mileage and gone through the railroad company shop, should come out a better locomotive than the day it was received from the builders. Whether in pooled service or otherwise, the standard of maintenance of each locomotive should be such as a first-class engineer would have it if running it regularly and being fully supported by the shop forces.

Inspection methods differ widely, but we find that the roads making the best fuel performance give particular attention to this feature and also to the following up of locomotive failures. Inspection must go further than looking after broken frames, wheel flanges and loose nuts.

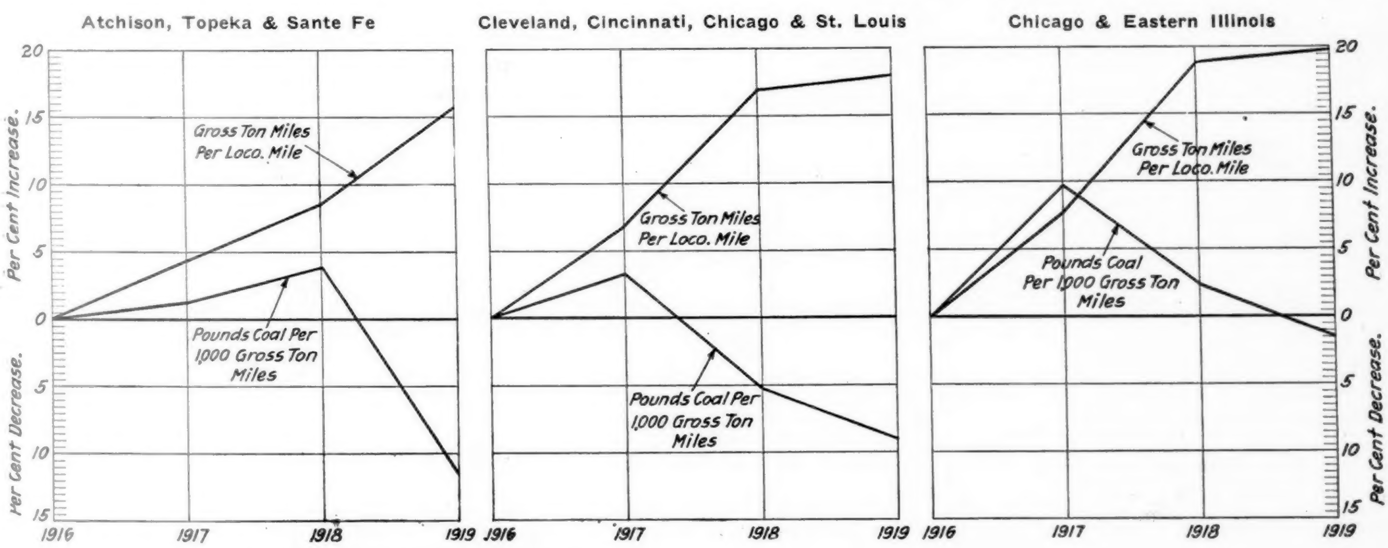
Delays

Certain roads have established standards of rating for movement at terminals and over divisions, for through freight trains, and check up each train daily. As an example, one division on a certain road, comparing with a similar period one year before, increased the train load 16⅔ per cent, decreased the average time of the freight train on the road 32 per cent and decreased the fuel consumption 13.1 per cent. It is claimed that the influence of the chief train dispatcher was the moving spirit in this. Another road decreased the average time of freight trains at terminals 11 minutes each. On both of these roads these standards have been worked out from actual observation.

Hot boxes and equipment failures are responsible for a great waste of fuel and frequently for reducing the average tonnage rating in order that the average sustained speed will overcome such delays. One road has made great progress in this. The average miles per box in service is as follows:

	Total No. hot boxes	Miles run per box
Passenger:		
First nine months—1917	1,615	48,964
—1918	1,072	63,957
—1919	373	147,067
Freight:		
First nine months—1917	29,225	18,434
—1918	26,151	23,479
—1919	12,810	30,033

Their system is such that when a delay occurs or a car must be set out for a hot box they can put their finger, so to speak, on the individual at the terminal responsible for the hot box. But primarily it is due to good shop practice—terminal attention. Good authorities claim that the average cost of a hot box is not less than $10, and when we consider the tonnage lost, wrecks, terminal switching charges, wheel



In the Months of September in Four Successive Years

changing, wages of men sent out, etc., we can readily admit that this is a conservative figure.

The gross revenue for one hundred-mile division for each 70-ton car of coal, the cheapest commodity we haul, is around $45. Not infrequently a train sets out three or four loads over a division because of car equipment trouble or hot boxes. One reason for stressing these points is that the most of the fuel economy bulletins are addressed to engineers and firemen. They are only links in the co-operative chain, and no one knows so well as they do how often their best efforts toward economy are defeated.

Locomotive Management

This, of course, goes back to the early training of firemen and to capable supervision. The use of fuel combustion and instruction cars and of special men with no other duties than that of employing and conducting examinations of firemen is being extended. Under certain conditions firemen are paid during the learning period.

The use of printed forms recording observations of road supervision is now in more general use. Some roads make a summary of such observations each month for the benefit of general officers, in order that they may know how supervisors are directing their efforts, and from these reports also the general condition of the locomotives may be noted. As to methods, there are a number of men on every division of every railroad that know the best way to fire and run each class of engine. Supervision is provided for the purpose of standardizing such methods. In my opinion some such standard form of report is necessary in order that general officers may know that the men who need instruction receive it. By a little study and care, very great reduction in fuel consumption can be and often is made.

A supervisory officer will ride with a crew with a tally counter, counting the number of scoops fired between given points. The fireman will say: "Had I known you were keeping a record I would have done better." We have, as a result of information furnished by supervisors, any number of records where a reduction of from 25 to 30 per cent or even more has been made just through the personal interest of the engine crew in their endeavor to demonstrate just what they could do. Road foremen of engines, fuel supervisors and traveling firemen in the Eastern region, carry a tally counter and hundreds of checks have been made. Many of these records are sent to roads all over the United States with the name of the crew and all of the data of the run.

Poor pumping, failure to regulate the cut-off at high speed, irregular adjustment of the lubricator, shutting superheater engines off at a high speed with valves in short travel, are the most prevalent wasteful practices. We know that these things should not be done, but the men often work under adverse conditions and sometimes are not instructed.

Heavy Firing

A case of heavy firing on a Pacific type locomotive on an 81-mile run with a six-car passenger train was brought to my attention. On the first trip which the traveling engineer rode the engine, 497 scoops of coal were burned, and on the second day, 435. With another fireman on the next trip, 405 scoops were burned, with the same train and an Atlantic type locomotive. A few days later after the fireman had been trying to see just how well he could do, the same locomotive with the same train burned 303 scoops, a reduction of 26 per cent and a reduction of 39 per cent over the Pacific type locomotive. In another case where one of the regional supervisors rode the locomotive—not a case of operation altogether, but largely due to the reverse gear creeping—an Atlantic type locomotive on a 55-mile run, burned 81 scoops of coal. A Pacific type on following day, with the same train and run with two additional slow-downs, burned 230 scoops of coal. While some of this fuel was burned on account of slow-downs, 124 scoops, of coal were burned in the first half of the trip or 50 per cent more for one-half of the trip than the Atlantic type burned for the entire distance. You have but to ask any locomotive fireman with as much as six months experience if it requires more coal for some engineers in the same service than for others, and a similar inquiry to engineers as to whether certain firemen burn more coal than others, will ofttimes bring the reply, "That we might better pay some fellows for staying at home." This seems rather strong, perhaps, but it is facts that we are dealing with and not theory. However, these are exceptions but as before stated, it is for these exceptions that supervision is provided.

Minor Wastes

Large locomotives on light passenger trains waste an enormous amount of coal. A committee of the Air-Brake Association estimated that six million tons of coal annually are wasted by controllable air leaks. Each square foot of steam heat line or other radiation surface uncovered, wastes one ton of fuel per year. If each locomotive on the New York Central Lines popped for ten minutes per trip, it would waste $144 per year and two scoops of coal wasted per trip through decks, at gangways or from overloaded tanks, would mean $54,000 loss, or enough to buy a modern locomotive.

Organization

Many suggestions have been offered as to types of organization. Obviously, the thing to do is to have such plans and purposes as will secure on each road the maximum amount of enthusiastic support from the chief operating officer down. Much of the strength of any organization lies in the general good opinion of those having to live with it. The supervision for locomotive operation and fuel costs has not received the same relative amount of attention as other branches of service. In the transportation department, below the rank of general manager, there are general superintendents, superintendents, trainmasters, etc. The mechanical department is officered likewise, but in locomotive operation we usually find one road foreman of engines on each division reporting to the master mechanic or superintendent. It does the master mechanic or superintendent no injustice to say that in the majority of cases, not having received their training through a similar branch of service and being charged with many other details of operation, the barometer of results being trains on time in one case and engine failures and shop appropriation in another, they are not always fully able to judge as to whether the road foreman or the fuel supervisor is getting full results. There is need for more general supervision. In the first place the road foreman's time may be taken up with a great many other things than the principal that his position is created for. At most there is one man for an average of about 35 locomotives, and since a great deal of his time is not given to locomotive operation, it is fair to assume that the equivalent is more nearly a man for each 50 locomotives. At $35,000 per engine (a conservative estimate) this makes a total of $1,750,000 worth of machinery that he is responsible for between terminals and also for the proper use of $372,000 worth of fuel annually.

There should be one general foreman reporting to the general manager or through the superintendent of motive power or other staff officer. He should have enough assistance to cover the job, whether working through the regular organization or with a special fuel economy staff of his own, but if he handles the work through the road foreman, there should be an adequate number of men—traveling firemen of fuel supervisors—who have nothing but locomotive operation and fuel to claim their attention and whom he can call on. Any man on the railroad, whether he be road foreman or otherwise, who is charged with the supervision of locomotive performance, should assume his full measure of responsibility. If the mechanical department is handling fuel economy, they,

of course, are responsible for calling attention to wastes in any other department and of keeping all the other departments interested.

Co-operation

In giving you these experiences I have tried to show something of the growing importance of the problem. The cost of fuel has increased tremendously and it will probably never be so cheap as now. Some practices, now more or less prevalent, the scope of which might be extended, improving thereby not only the locomotive service, but the railroad machine as a whole are worth mentioning:

First—Better railroad fuel through better inspection and closer co-operation between the mine operators and the railroads.

Second—Improved locomotive conditions by closer inspection, distribution and maintenance.

Third—Improved road and terminal movement by establishing standards of performance and following up of delays.

Fourth—More scientific locomotive operation through better educational methods, supervision and records.

The charts that accompany this paper will serve to illustrate the direct relation that the average gross tons per locomotive mile bears to the unit fuel consumption. A good fuel performance means successful train operation and the maximum per cent of potential tonnage movement. These charts show the close relation between the weight of the train and the pounds of fuel used to earn one dollar.

Discussion

H. C. Woodbridge (Supr. Fuel Conservation Section): I rode on a locomotive recently that had a power reverse gear on it that would stay put. One notch made a difference in the action, and it would stay where you put it. You must make a drive on the transportation department men; you must not stop with the trainmaster and the despatcher, although, the despatcher can save more fuel than several first-class firemen. One of the big railroads has ore trains running out of the Lake Erie ports; one of their heavy trains has a record of having stopped 22 times in 125 miles. That was an old record, and they decided that at least 12 of those 22 stops were unnecessary—and they have been eliminated. But do not stop with the despatcher and the trainmen, or the superintendent, but go to the men at the top.

W. L. Robinson (Division M. M.; B. & O., Washington, D. C.): What has appealed to me most in Mr. Collett's paper was a matter that was passed over rather hurriedly, but it is something that I have made a considerable study of, and that is the matter of measuring the actual amount of coal that is used on the individual locomotive. I think that is the greatest opportunity for fuel saving that we have left.

J. W. Hardy (Fuel Supervisor of the Southwestern Regional District): I do not believe there was ever a time in the history of our country when it was as necessary to have the right kind of supervision as it is now. When men had regular engines, and used to come in and report their work, they gave their locomotives supervision that they do not get today. Their engines are now delivered far from the shop and the work report is sent in by someone else, so that there is not the personal contact that there used to be when the enginemen were personally acquainted with the men who did the work. That, in turn, calls for closer shop supervision. The shopmen do not do their work with the same interest that they did, even in pre-war times. Shorter hours contribute something to that; one man tears a job down, and another one finishes it; in fact, there are many things that require closer supervision. It has only been a few years that we have had locomotive inspectors; that work used to be done by the regular locomotive engineer, and was done much better than it is done by the ordinary locomotive inspector, because the engineer is more interested in the result that he would obtain on the road than the man who just simply inspects the engine. The growing demand for better supervision cannot be emphasized too much.

We need better supervision of our stationary steam plants. While it is true that only about 12 per cent of the total fuel used is burned in the stationary plants, there is a great deal of it used very wastefully. The consumption of fuel always increases in the winter time, and when that increase takes place there is a corresponding increase in waste, so that it is very important for us to turn our attention to all the little leaks.

In addition to the coal used by American railroads, 5,000,000 barrels of oil are used annually. Oil is being used in greater quantities daily, especially in the Southwest, and this trouble with the coal miners is undoubtedly going to make additional demands upon the production of oil. So I just want to mention that there is waste in oil, just the same as there is in coal. Sometimes in locomotive operation, the loss is greater on oil than it is on coal

I just made a trip over some of the oil burning lines in the Southwestern region; there are several things that I learned—small things—but they contribute a good deal to the waste of oil. The matter of the quality of sand used has a great deal to do with the results that you get, and the way it is used has a great deal to do with it. I mention this because I know some of you gentlemen in this meeting are interested in the oil question. Yesterday I received from the Texas Pacific one of the most complete instruction books on the use of oil in locomotives that ever came out in this country. It contains the combined oil knowledge and experience of men in the Southwest and in California who have been using oil in locomotives for several years, and it is gotten out in the form of an instruction book by the Texas Pacific.

E. Hartenstein (Genl. R. F. of E., C. & A.): We have six men in the road foreman's department, and we have made it our business in the last six or eight months to station ourselves at the terminals when locomotives are set out for service to give them a thorough inspection. If we find that any defect exists that would cause an excessive use of fuel the locomotives are sent back and are not permitted to go.

We do not do that very often before the roundhouse foreman aims to see that the locomotives are put out in better condition.

We assume the same authority with regard to continuing an engine in service that is exercised by the federal inspectors; if we do not exercise that authority, we have to explain why to the man above us.

Eugene McAuliffe: A survey of the actual results obtained during the first nine months of this year, and projecting the curve through to the end of the twelve months, shows that after making an arbitrary allowance of seventy-five cents per ton to cover the cost of haul on user's rails, that the reduction in the cost of fueling locomotives and stationary plants including miscellaneous railroad fuel consumption for this year, as compared with last year, calculated on the basis of pounds of coal per unit of service will exceed $45,000,000. The expense of operating the Fuel Conservation Section is only a trifle over $100,000 per year.

The fuel problem is a bigger one than the fuel bill to the railroad. The coal mines of this country today furnish you 38 per cent of your freight traffic—your freight tonnage. They give, in addition, a very material collateral tonnage, in the shape of in-bound machinery, timber, steel, rails, merchandise, and perhaps a measure of passenger traffic that is not small. The mining industry as a whole, both fuel and metal, furnishes the railroads of the United States 68 per cent of their freight traffic. So, from a revenue earning standpoint, there is room for a direct and compelling partnership between the railroad industry and the mining industry.

The job has grown beyond the locomotive engineers and

ex-locomotive engineers. It is a job now, just as it has been for some years past, but to a greater extent now, that belongs to the highest executive officers of the railroads. It is too big to be treated as a secondary proposition. The railroads today are paying an average of $4.05 per ton for coal, excluding the item of haul on user's rails, which I estimate will not be less than 75 cents per ton. I predict that a further increase of perhaps one dollar per ton will be added to the existing mine price. That will add $100,000,000 or $150,000,000 more to the railroad's fuel bill annually—a further incentive to our railroad executives toward taking hold of this problem.

The railroads of this country do not yet know how to buy coal; they do not yet know how to inspect coal or how to receive coal; and while the proposition of how to use it is a tremendously compelling one, reforms in purchasing and inspection methods will, if made, prove of great value.

There is a direct relation between fuel economy and the average weight of train, and if you secure the highest possible advantage through fuel economy the weight of the train will take care of itself. The savings effected not only will be those which flow from the decreased volume of coal consumed, but will be perhaps exceeded along other lines, through the heavier weight of trains, and a general reduction in operating costs.

RAILROAD ADMINISTRATION NEWS

In General Order No. 65, dated December 10, Director General Hines says:

"Grievances affecting employees belonging to classes which are or will be included in national agreements, which have been, or may be, made between the United States Railroad Administration and employees' organizations will be handled as follows:

"(a) Grievances on railroads not having agreements with employees, which grievances occurred prior to the effective date of any national agreement, will be handled by railroad officials in the usual manner with the committees and officials of the organizations affected for final reference to the Director of Labor, as provided in Circular No. 3 of the Division of Labor. Grievances on railroads having agreements with employees, which grievance occurred prior to the effective date of any national agreement, will be handled by railroad officials in the usual manner with the committees and officials of the organizations with which the agreement was made, for final reference to railroad boards of adjustment, as provided in general orders creating such boards. Decisions made as the result of such reference will apply to the period antedating the effective date of such national agreement, and, from the effective date of that agreement, will be subject to any changes that are brought about by national agreement.

"(b) Grievances which occurred on the effective date of any national agreement, and subsequent thereto, will be handled by the committee of the organizations signatory to such national agreement for final reference to the appropriate railroad board of adjustment, except on roads where other organizations of employees have an agreement with the management for the same class of employees, in which case grievances will be handled under that agreement by the committees of the organization which holds the agreement for final reference to the Director of Labor, as provided in Circular No. 3 of the Division of Labor."

Foremen in Mechanical Department Classed as Officers

Because of the exceptional importance of the work of supervisory foremen in the mechanical departments, and the fact that economical and efficient shop operation depends so largely upon their efforts and co-operation, W. T. Tyler, director of the Division of Operation, has issued a circular letter to the regional directors stating that it is desired that their classification, working conditions and privileges be made definite and uniform.

To that end the director general directs that general foremen, roundhouse foremen, departmental foremen and assistants will be classified as officers and will be given consideration and advantages attaching to officers of similar rank in other departments, as follows:

(a) Reasonable period of time lost on account of sickness without loss of pay.

(b) Two days off each month for all salaried foremen whose tour of duty consists of seven days per week.

(c) Two weeks' vacation a year with pay for all salaried foremen who have acted as officials continuously for one year or more.

(d) Privilege of resigning instead of being shown as discharged or dismissed.

(e) When charged with an offense likely to result in dismissal, a hearing to be given by a superior officer other than the immediate superior, at which hearing the foreman in qusetion may be represented or assisted by any other foreman whom he may select for that purpose.

(f) Card transportation to be granted to all salaried foremen, the extent of such transportation to be based on the general practice for other division officers and the importance of the position the foreman occupies.

The letter says: "It is not possible to lay down a definite seniority rule, because ability and merit are of paramount importance in this highly responsible work and, in any event, must govern, but where the ability and merit of two men are equal, the choice of positions on a division should, as far as practicable, be determined upon the basis of seniority. I am sure that the uniformity brought about by the above rules will result in more loyal and efficient service by the foremen affected and will reduce complaints to a minimum. Will you please take action to have this put in effect at once?"

ORDERS OF REGIONAL DIRECTORS

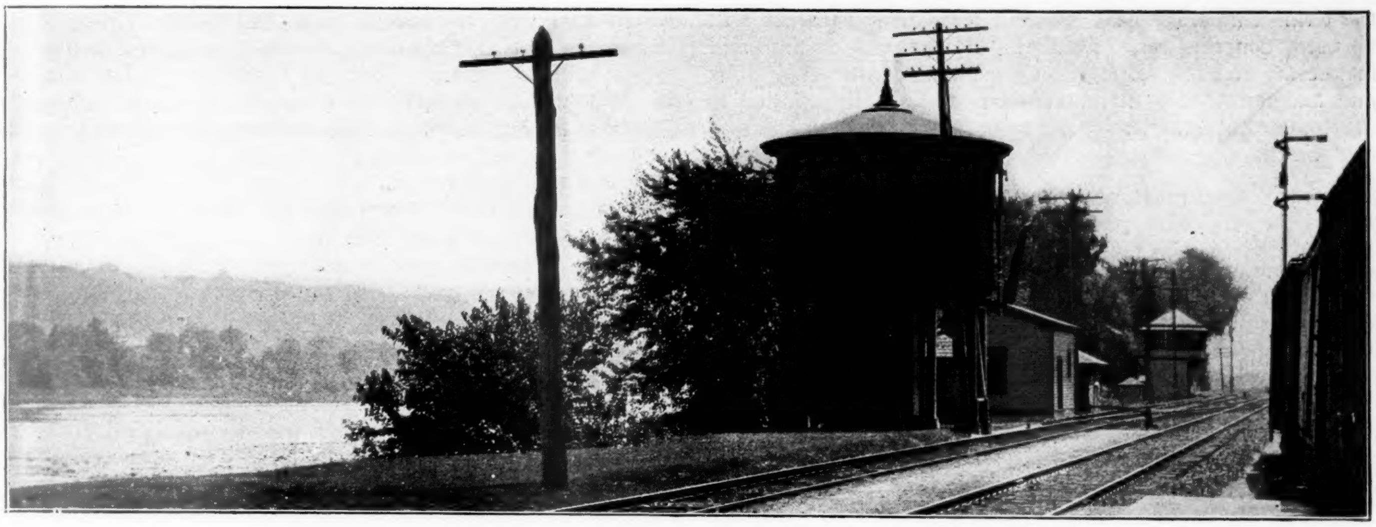
Incomplete Brakes on Gondola Cars. — Supplement 2 to Circular 201 of the Southwestern regional director states that 500 U. S. standard hopper cars, allocated to the Pere Marquette, built by the Ralston Steel Car Company, and numbered 13,000 to 13,499, were placed in service without sheave wheels on brake and hand brake pull rod. The circular instructs that, where these cars are found with sheave wheels omitted on the end of the hand broke rod, changes should be made at once, regardless of ownership.

Employment of Apprentices.—The Northwestern regional director, file 42-1-100, states that statistics show that while there are 42,193 journeymen in the mechanical departments of the railroads in this region there are only 1,880 apprentices, or a ratio of one apprentice to 22.44 journeymen. Under the national agreement 6,559 additional apprentices can be employed. The circular adds that diligent efforts should be made to obtain the full ratio of apprentices, and special attention should be given to see that they are thoroughly instructed in the various branches of the trade in order that properly trained mechanics may be provided for the future.

Freight Car Distribution.—Supplement 18 to Circular 70 of the Northwestern regional director contains the following instructions, which are intended to assist in meeting the increased demand for grain cars:

"Effective at once, arrange to give the repair of grain cars preference over other classes of equipment. Additional forces should be employed where they can be used to advantage. Report as of Saturday of each week the number of cars repaired and made fit for grain loading for the preceding week.

"Reports continue to reach me of grain cars used in other service where other equipment is suitable and available. Unless cars are being loaded directly into grain-producing territory, instructions should provide for the use of non-fit cars. From now on special attention must be given to supplying grain cars, particularly for the heavy corn crop, which now demands attention."



BOILER COMPOUNDS; THEIR NATURE AND USE

Chemical and Mechanical Agents Used to Prevent or Remove Scale; Quantity Required and Cost

BY W. S. MAHLIE

THE question of treating boiler feed water has been one of the most neglected items in railroad operation. The problem of economy and efficiency looms up with greater importance each day. The saving of fuel, the cost of which is no small portion of the operating expenses, has been very forcibly impressed upon railroad men. Outside of actual wastes in poor coal, insufficient combustion, etc., one of the important factors of fuel conservation rests upon the quality of the boiler feed water. In addition to the loss of fuel due to untreated water, there is the cost of the locomotive being out of service, new flues and fireboxes, labor in caulking and washing boilers.

It is not intended in this article to convey the idea that all feed waters should be treated with boiler compounds. By far the most of them should be treated in a regular water treating plant. The cost of treating water by the regular plants and by boiler compounds should be carefully compared and the results obtained from these treatment should also be studied. Boiler compounds are not to be regarded as absolute cures for all boiler troubles. They seldom do more than lessen the bad water conditions, the extent of which depends upon the original water and, of course, the compound used.

It should be kept in mind that a steam boiler was made to furnish steam; not to treat water, consequently the boiler should be supplied with good water so that it can perform the duty which is required of it. A person would hardly drink typhoid germ laden water and then take medicine to prevent typhoid, but rather, would use a pure water which would not produce disease. So it is with boiler water, an ounce of prevention is worth a pound of cure.

Boiler compounds are of many different compositions, some good, some bad, some indifferent. Viewed with the eyes of the practical water purification man, they are regarded as "patent medicines." Like patent medicines they are much advertised and all sorts of good and bad testimonials are recorded following their use. All boilers are not alike, neither are all boiler waters. For this simple reason no compound can be developed which is a sure cure for all boiler troubles. Some may be good for one thing, some for another.

In view of the many compounds sold, I have undertaken in a general way to show their classes, possible reactions, and other data, and let the buyer of the compound judge for himself as to its merits.

Requirements of a Boiler Compound

A successful boiler compound must fill the following requirements: (1) It must make the water non-corrosive. (2) It must hold in suspension, or colloidal form, all of the salts which would give rise to an incrusting precipitate. (3) It must put the water in such a condition as to keep it from foaming or priming. (4) It must be a chemical or compound of such a nature that it can be safely stored and kept from deteriorating. (5) It must be of such a nature that it can be easily measured or weighed and applied. (6) Its cost must compare favorably with other methods of feed water treatment.

It is not known exactly when boiler compounds came into general use. We find that during the development of the oil fields, it was a common practice to put a small amount of crude oil in a boiler to remove scale. Around saw mills it was also a practice to dump saw dust into the boiler to loosen scale. Thirty years ago bran was used in engine tenders to prevent scale in the boilers. Soda ash was used as early as 1864. Thus it will be seen that the use of boiler compounds was more in the nature of an evolution than a discovery.

Purposes for Which Used

Compounds are generally used for either one or more of the three following purposes. (1) To remove and prevent scale. (2) To prevent corrosion. (3) To prevent foaming. Only compounds of the first and second kinds will be considered here because, strictly speaking, the third kind are not boiler compounds, but anti-foaming compounds.

Classification

The boiler compounds may be roughly divided into three classes. (1) According to chemical action. (2) According to mechanical action. (3) According to combined chemical and mechanical action. In the following discussion

the terms temporary hardness and permanent hardness will be used, denoting respectively the bicarbonates of lime and magnesia; and the sulphates, chlorides and nitrates of lime and magnesia. The term incrustants is usually applied to the latter, but most practical men prefer the term permanent hardness.

Class I. Chemical Action

Soda ash or *sodium carbonate* is used more than any other chemical and is the base for practically all boiler compounds. Soda ash usually runs about 98 per cent pure sodium carbonate (Na_2CO_3). Another form known as soda crystals runs about 34 to 35 per cent (Na_2CO_3) the balance being water of crystallization.

The action of soda ash in the boiler is the same as in the regular treating plant outside the boiler. It removes the hard scale or permanent hardness, and neutralizes acids which cause corrosion. Soda ash was used in England as early as 1864. Too much soda ash should be guarded against as it will cause foaming when used in excess.

Sodium silicate or *water glass* is coming into extensive use as a boiler compound. It is seldom applied alone, but most always in combination with soda ash or tannin. Sodium silicate has the advantage of acting on both temporary and permanent hardness. When sodium silicate acts on temporary hardness one part of soda ash or sodium carbonate is liberated for each part of silicate added; this sodium carbonate is then available to act on permanent hardness.

In using sodium silicate the same precautions should be used as in all sodium compounds, since excesses cause foaming. Sodium silicate comes to the market in liquid form.

Sodium hydrate or *caustic soda* is not used as much as formerly and acts on both temporary and permanent hardness and neutralizes acids. Like sodium silicate in its action on temporary hardness each part of it liberates an equal amount of sodium carbonate available for action on the permanent hardness. Caustic soda is not available for removing sulphates of lime and magnesia alone, without the presence of enough temporary hardness, since by the action of caustic soda, hydrates of lime and magnesia are fgormed.

An excess of caustic soda is probably one of the worst things to get into a boiler, because like other soda salts it causes foaming, and has a decided action on brass valves and fittings. It also causes iron to become brittle when in concentrated solution. Caustic soda is bad material to handle, since it takes up water very readily from the air. It burns the skin and clothing, causing very painful sores, which are slow to heal. Caustic soda is sometimes mixed with soda ash and is known as Special Alkali. The approximate composition of this material is 40 per cent caustic soda and 60 per cent soda ash.

Tri-sodium phosphate was formerly used to a great extent, but is not used so much as present. It is distinctly a boiler compound since the reactions between lime and magnesia compounds are not complete at ordinary temperatures, but the water must be boiled in order to obtain the maximum effect. Like the silicate and hydrate of sodium in its action on temporary hardness it liberates an equal part of sodium carbonate, which can be available for further action.

The di-sodium has also been used as a boiler compound. The precipitates of sludge obtained from the action of the phosphates are very light and flocculent, and are easy to blow out of the boiler. It is claimed by some that sodium phospates are the most efficient boiler compounds in use. Sodium phospate was used in England as early as 1879 under the name of Tripsa.

Sodium fluoride is also distinctly a boiler compound. Dr. Doremus patented the use of this chemical as a water softening reagent. One of the claims made for this material is that one-fourth of the theoretical amount required will produce a sludge which will not stick to tubes or the sides of a boiler, and is very easy to blow out. Another advantage claimed is that in using this compound, no volatile materials escape with the steam. No records were to be found anywhere describing the actual success with this compound.

Sodium oxalate has been recommended for use to prevent scale, but no instances could be found where it had been used. The reaction would be upon both temporary and permanent hardness with the formation of equivalent amounts of sodium carbonate.

Sodium chromate can be used to precipitate lime compounds, temporary and permanent. Another peculiar property of chromates is that they render iron passive to corrosion.

Sodium borate or *borax* has been used to some extent as a boiler compound. Lime compounds are precipitated cold, as borates, but magnesia compounds are only precipitated under the heat of the boilers.

In all the preceding discussion, sodium compounds only have been considered. It should be remembered that potash compounds will act in a similar manner, but due to the high price of potash compounds they are not used for this purpose.

Barium salts. In many respects the barium compounds are the ideal boiler compounds, since no soluble alkaline salts are left in solution by their use. On the other hand their cost is much greater, due to the larger amounts required for reactions, and also to the increased cost per pound compared with an equal weight of sodium compounds. In addition barium salts are poisonous and consequently are not desired, even around boilers, where any one might accidentally drink some of the water. Barium salts are ideal for incrusto-corrosive waters having high sulphate content, which otherwise would cause foaming by treating with sodium compounds.

The principal form in which barium is used is the hydrate. The carbonate can be used, but it is said it is not in as extensive use as the hydrate. The aluminate of barium should be a very desirable theoretical treatment, since it would also entangle and precipitate mud and other materials in suspension. Barium hydrate acts on both temporary and permanent hardness and acids. The carbonate of barium is not used much as a boiler compound, but more as a softening reagent in proper chemical treatment tanks. It is also said that barium carbonate is not very satisfactory on magnesium waters.

Lime. It formerly was a favorite practice in the French navy to add just enough lime to boiler waters to make them slightly basic. The lime reacts on the free acids, temporary hardness and magnesium compounds. The introduction of line, however, adds a very bad feature to the acid waters, inasmuch as it will give rise to an extremely hard scale, and the acid is only removed or neutralized at the expense of adding hard scale to the boiler.

The writer has known of one case in particular where the addition of lime to a boiler gave good results. It was during the spring when the periodical acid conditions prevailed in the Ohio river. The flues and fireboxes of locomotives using this water began to leak so badly, that as one boiler maker said, "they wouldn't hold shelled corn." A small amount of lime was placed in the tender of one of these locomotives and the leaking disappeared at once.

Lime comes to the market in two forms, the lump or quick lime, and the hydrated lime. The lump lime is usually the cheapest and an equal weight of it is more efficient than the hydrated lime, since the hydrated lime contains about 25 per cent of combined water. The lump lime, however, becomes air slaked on exposure to air, and is then useless for water softening, while the hydrated lime does not slake. Lump lime runs about 88 per cent pure. When only small amounts of lime are used, the hydrated is probably the best to use, since it can be stored and does not slake. Lime

acts on all free acids, on temporary hardness and on magnesium compounds.

Chalk or Powdered Limestone. The use of this was advocated by the celebrated French chemist LeChatelier. It was introduced to act on sulphate of iron, and to act mechanically by being incorporated with the precipitated calcium sulphate or hard scale. It is not known whether or not successful results were obtained by its use.

Tannin Compounds and Wood Extracts. Tannins are used as scale preventatives in boilers. They are distinctly boiler compounds, and precipitate lime and magnesium as a light bulky precipitate. Tannins are seldom used alone, usually combined with sodium carbonate, sodium hydrate or sodium silicate.

Tannins are obtained from a great many sources, some of them being hemlock bark, oak bark, Canaigre, Quebracho, Palmetto root, Catechu, Gallnuts, Sumac, Valonia and Divi-Divi.

When tannin is used it leaves a very light friable deposit which is easy to remove. It is claimed that tannins are among the safest and best materials to put into a boiler. Some persons object to tannin, claiming that it would cause corrosion. No cases of such action, however, have been brought to light. The different bark extracts are mixtures of tannin and other closely related materials which act in a manner similar to tannin.

According to De Le Coux when a tannin, either free or combined with sodium compounds, is added to water, quite a number of complex changes take place, and the resulting action is that the tannates, gallates, and hydrogallates are precipitated in a mixture.

Zinc and aluminum.. Zinc or aluminum have been introduced into boilers to prevent corrosion. The theory is that zinc and aluminum having a higher solution pressure than iron, will go into solution instead of the iron. This practice of adding zinc was started in 1881. Zinc has been much used, and even today is found in some compounds.

Commander Lyons of the U. S. Navy in 1913 made some interesting experiments on the use of zinc, and found that corrosion was lessened to some extent for a few days, and that then the zinc became coated with an oxide and the electromotive character of the zinc changed, and that instead of the zinc being attacked the iron became attacked. As a result the use of zinc was discontinued and 3 per cent normal alkaline strength of soda ash was used, which gave excellent results.

Sugar, Molasses and Glycerine. It has been claimed that sugar, molasses and glycerine are good scale preventatives, that they dissolve the lime and magnesia salts and hold them in solution, thus preventing a deposit. A number of investigators have studied the action of sugar on lime sals, and found that the oxide is dissolved, and that carbonates and sulphates are little affected. Inasmuch as lime-oxide is not present in boiler water the use of sugar could hardly be recommended. A series of tests was made to determine the solubility of calcium carbonate. Solutions containing one per cent, five per cent and ten per cent of sugar were allowed to act on calcium carbonate, with continuous shaking for 1½ hours. Solutions of glycerine of the same strength were allowed to act in the same way. Identical solutions of sugar and of glycerine were also allowed to act on calcium carbonate by boiling under 18 lb. pressure for two hours. In all cases the solubility was very slight amounting only to traces.

Another series of tests was conducted in a similar manner using calcium sulphate in the different concentrations of sugar and glycerine. It was found that while there was quite an amount of the calcium sulphate dissolved, it did not exceed in any instance the amount normally soluble in water alone. These experiments prove the fallacy of using sugar and molasses as scale preventatives.

Class II. Mechanical Action

Clay. De La Coux says—"Clay is a fairly good scale preventer, but there is danger of clay working into the machinery." It would appear to be a rather peculiar proceeding to add clay to boiler water, because most boiler waters contain clay and other suspended material which it is desired to remove. Clay could have no chemical action, and if added in sufficient quantity to act mechanically it would be almost sure to deposit on tubes and sheets and cause mud burning.

Talc, powdered limestone or *chalk, pumice* and *ground glass* would all act in a manner similar to clay. No advantage can be seen in the use of any of these since they all are inert chemically and they are not of a nature which would appear to benefit scale by being incorporated with it.

Starch, glucose, dextrin, potatoes, slippery elm, artichokes. Any number of materials of a similar character have been proposed. Their action, if any, is entriely mechanical. It is claimed that these substances dissolve in the water and form a sort of gummy gelatinous coating around the grains of deposited scale and prevent them from sticking so tightly together.

Dextrine, starch and glucose are more frequently used as binders in boiler compounds to hold the different constituents together, either in the shape of a ball or a brick.

Ground hoofs and *horns* have been used to prevent scale. When boiled these would yield glucoses and gelatines which would act as before stated.

Oils. The addition of oil to a boiler for preventing scale has been practiced for a long time. The action of course is entirely mechanical. Several explanations as to the action have been made. Some say the oil "rots" the deposited scale. Others say the oil envelopes the precipitated scale and prevents it from sticking. Others say the oil is attracted to the hot tube, becomes overheated, and forms a tiny explosion, which breaks or knocks off the deposited scale.

The benefit of oil addition would appear to be questionable. Christie in his book, Water Purification and Its Use in the Industries, devotes an entire chapter to the subject of oil in feed water, and after describing a number of oil filters says, "The use of oil in boilers to loosen scale is a positive detriment." He further says, "If oil must be used it should be a mineral oil, since animal and vegetable oils will very likely break down. forming free fatty acids and cause corrosion.

The writer, personally, has seen a great many boiler tubes, very badly bagged or blistered, caused by oil in feed water accumulating in a spot and becoming locally overheated. After installation of oil filters the bagging was entirely eliminated. After such experience one would hardly recommend that oil be used in a boiler.

Fats. Fat either alone or mixed with other substances has been proposed and used. It was probably the intention to coat the inside of the boiler with a coating of grease to prevent the particles of scale from adhering to the inner surfaces. No cases have been found recorded where this was entirely satisfactory. It usually caused local overheating where the grease was applied and the hot flame came into contact with the tube. In Belgium the custom has been for some time to rub the inside of the boiler with a mixture of tallow and amorphous graphite.

Rosin and *Tad.* Rosin has been used in a manner similar to fats. When tar was used it was mixed with five parts of oil before being applied.

Graphite. Literature on the use of graphite as a boiler compound is very scanty. After a thorough search, numerous instances were found where graphite was used, but no record of the results obtained were shown.

Graphite cannot be used other than from a mechanical standpoint in removing scale, since it is inert at ordinary temperatures. The producers of graphite say graphite will

not act chemically, but when the scale is deposited the graphite intermingles with it and prevents it from becoming a compact mass, and keeps it soft and easy to blow out. They also say that the graphite will work through the accumulated scale to the tubes and shell of the boiler and loosen the deposited scale. It is doubtful whether the graphite will do this, but if the graphite were coated on the inside of a new boiler, it would prevent much scale from adhering to it.

W. A. Converse, in an address before the Railway Club of Pittsburgh, May 22, 1914, made the following statement: "It is an absolutely well known fact that there is no possible chemical reaction between graphite and any substance found in boiler feed waters. Any action that might possibly be brought about that might be considered beneficial would have to be of necessity mechanical. It is absolutely impossible for graphite to permeate through any formation in the way of scale of anything like ordinary density. You cannot force it through with a pressure of 60 will probably not permeate the scale in practice in the boiler.

"There is this possibility. If you could get into the lb. I know. If you cannot force it through that way, graphite boiler and with a brush or otherwise polish the interior of the boiler itself as is done on a stove with stove polish, it would possibly smooth the surface of the metal and therefore prevent for awhile the adhesion of the particles of scale. But try to do that on a wet surface and you will find you are up against a very difficult job. And when applied to dry metal, graphite does not last long in contact with water. Consequently it cannot last long in a practical way."

In an article in the Journal of Industrial and Engineering Chemistry, May, 1916, H. K. Benson and O. A. Hougen describe experiments at the University of Washington. They say, "Graphite has no effect in holding suspended matter."

Some time ago a piece of peculiar looking boiler scale or deposit which had been removed from a Stirling water tube boiler was shown to the writer. One of the flues had been burned and upon examination this piece of scale was found. The material was a very hard, black amorphous looking mass. It was also attracted by a magnet. The analysis of the scale showed:

Graphite	None
Silica, SiO_2	1.36 per cent
Magnesium oxide, MgO	3.66 per cent
Sulphuric anhydride, SO_3	21.73 per cent
Calcium oxide, CaO	21.19 per cent
Metallic iron, Fe	50.65 per cent

Upon recalculation to the possible combinations the following remarkable combination appeared:

Silica	1.36 per cent
Magnesium oxide	3.66 per cent
Calcium sulphide	19.58 per cent
Calcium oxide	5.95 per cent
Ferroso-ferric oxide	69.95 per cent

From this analysis it would appear that, first a mixture of calcium sulphate, calcium carbonate, and magnesium hydroxide, with a small amount of silica had deposited in the usual manner. Then due to this sulphate deposit the tube became overheated at this point, not, however, to the maximum. This overheating resulted in a decomposition of the calcium sulphate as shown by the equation.

$$CaSO_4 = Ca_3 + CaO$$

This SO_3 (sulphuric anhydride) then with the water formed an acid which attacked the iron and formed iron sulphate. This iron sulphate with more or less carbon dioxide, formed a deposit of iron hydrates and carbonate. As the deposit became larger the overheating became more pronounced and due to the graphite present, finally assumed very high temperatures. These high temperatures and the graphite reduced some of the iron, so that a mixture of ferrous and ferric oxides was formed, and it happened that they were present in just the proper amounts to form $Fe_3 O_4$.

The temperature attained in this case must have been very high and it readily can be seen that it was very dangerous to operate this boiler. Howver, it is unlikely that another case like this would occur again, especially going to the extremes this one did. However, one can see the danger of having something in a boiler which is liable to deposit on the flues.

Another piece of boiler scale from a stationary engine boiler, which did not carry such a high pressure as the preceding one, was examined. This scale was grayish in color, very friable, and easy to remove from the boiler. Graphite could be seen permeating the scale throughout.

The analysis was as follows:

Water	0.14 per cent
*Ignition loss	18.76 per cent
Silica	3.52 per cent
Iron and alumina	1.38 per cent
Calcium oxide	39.46 per cent
Magnesium oxide	4.99 per cent
Sulphuric anhydride	31.94 per cent
Total	99.19 per cent

*The ignition loss contained about 1 per cent free graphite.

Careful inquiry showed that the scale formation in the boiler was not lessened, however, the scale was changed from a very hard character to a rather soft mushy one. The use of graphite was discontinued in this case as unsatisfactory. These and some other similar experiences have convinced the writer that graphite should never be placed in a boiler to stop corrosion or to prevent the formation of scale.

Class III. Chemical and Mechanical Action Combined

Under this head all kinds of mixtures of the materials described in the preceding pages are used. The following are some actual analyses of commercial boiler compounds:

TABLE I

QUANTITY OF CHEMICALS REQUIRED TO ACT ON THE VARIOUS DETRIMENTAL SUBSTANCES IN WATER

To Act on One Part of	Lime, Ca O	Sodium carbonate, $Na_2 CO_3$	Caustic soda, Na OH	Tri-sodium phosphate, $Na_3 PO_4$, 12 H_2O	Sodium silicate, $Na_2 Si O_3$	Sodium fluoride, Na F	Barium hydrate, Ba (OH) 2 100 per cent	Barium carbonate, $Ba CO_3$	Barium chloride, $Ba Cl_2$, 2 H_2O	Borax, $Na_2B_4O_7$, $10H_2O$	Tannin, $C_{14} H_{10} O^9$
Calcium carbonate as bicarbonate, $Ca CO_3$	.560	1.060	.800	2.530	1.220	.840	1.712	.....	.....	3.820	6.440
Calcium sulphate, $Ca SO_4$	.....	.786	.588	1.870	.897	.618	1.259	1.449	1.796	2.809	4.735
Calcium chloride, $Ca Cl_2$	.....	.962	.721	2.283	1.100	.756	1.544	.....	.....	3.441	5.802
Magnesium carbonate as bicarbonate, $Mg CO_3$	.660	1.262	.952	3.015	1.452	1.000	2.032	.....	.....	.....	7.667
Magnesium sulphate, $Mg SO_4$	.467	.890	.667	2.111	1.017	.700	1.423	1.642	2.036	.....	5.367
Magnesium chloride, $Mg Cl_2$	.....	1.124	.842	2.666	1.284	.884	1.800	.....	.....	.....	6.779
Carbon dioxide, CO_2	1.272	2.410	1.818	5.757	.....	.....	3.895	.....	.....	.....	.....
Sulphuric acid, $H_2 SO_4$	.571	1.080	.816	2.583	1.245	.....	1.748	2.010	2.492	.....	.....
Hydrochloric acid, H Cl	1.534	2.904	1.096	6.931	1.671	.....	2.443	2.700	.....	.....	.....

Note.—This table is based upon 100 per cent pure materials. These chemicals are rarely over 100 per cent pure, consequently a proportionately larger amount must be used than is shown on the table.

(1) A bluish green liquid, having a strongly alkaline reaction:

Specific gravity	1.40 per cent
Sodium silicate	45.79 per cent
Copper sulphate	1.69 per cent
Iron and alumina	0.17 per cent
Water (by diff.)	53.35 per cent

(2) A greenish yellow solid material, put up in sticks about 1¼ in. by 1¼ in. by 12 in.

Moisture at 105 deg. C.	38.43 per cent
Organic material, presumably tannin and binding material	9.15 per cent
Sodium silicate	7.00 per cent
Alkaline chromate	6.45 per cent
Free metallic mercury	0.62 per cent
Sodium carbonate (by diff.)	38.35 per cent

(3) Volatile—probably spent tan liquor	52.83 per cent
Organic—probably spent tan bark	15.31 per cent
Residue sodium carbonate	30.82 per cent
(4) Moisture	9.69 per cent
Metallic aluminum	3.93 per cent
Inert material	71.63 per cent
Graphite	13.75 per cent

This material was claimed to be as follows:

Aluminum	5 per cent
Graphite	87 per cent
Pumice	8 per cent
(5) Moisture	16.79 per cent
Sodium carbonate	50.72 per cent
Inert material	1.67 per cent
Graphite	9.35 per cent
Organic { Dextrin / Binder }	21.47 per cent

The following is a list of some patented boiler compounds:

(1) 75 parts tri-sodium phosphate.
8 parts ammonium sulphate.
17 parts soda ash.
(2) 6 parts zinc dust.
48 parts soda ash.
18 parts bark extract.
10 parts dextrin.
4 parts graphite.
14 parts water.

(3) Sodium carbonate	64 per cent
Tri-sodium phosphate	15 per cent
Dextrin or starch	1 per cent
Tannin compound	10 per cent

(4) 70 parts di-sodium phosphate.
20 parts borax.
10 parts sodium carbonate.
(5) 70 parts sodium phosphate.
20 parts borax.
19 parts calcium carbonate.

(6) Soda ash	75 per cent
Meco tannin extract	25 per cent

(7) 2 parts H_2O (water).
1 part HCl (hydrochloric acid).
0.01 part Hg Cl_2 (bichloride of mercury).

(8) "An alkaline hydroxide and catechu together with an organic substance containing much water, such as potatoes, are heated until reaction ensues."

(9) Ninety-eight per cent amorphous graphite, with a neutral organic vehicle.

(10) "A solution of saponin, a neutral vegetable oil, such as eucalyptus oil, a basic alkaline salt, and an inactive vegetable colloid preferably carrageen jelly."

(11) Hog lard or horse fat	100 parts
Pine soot or graphite	3-19 parts
Benzine or a petroleum or mineral oil	1-5 parts

(12) "A mixture of soap and acid, nitric and hydrochloric, fat, resin and petroleum oil."

(13) Naphthalene in causic soda, Glaubers Salt (Sadium Sulphate) in ammonia, calcined soda, alum and ultra marine."

(14) "Hydrochloric acid and a solution of bromide in potassium bromide and water. Add a mixture of sodium sulphite, sodium carbonate, or bicarbonate to remove free acid and bromine.

(15) Pure graphitic iron and one to four per cent of zinc.

(16) Glycerol	15 per cent solution
Oleic acid	8 parts
Petroleum	20 parts

(17) Zinc and zinc alloys and leather.
(18) Benzine, lamp black, animal fat, lard or horse; and tallow.

(19) Graphite	50 oz.
Soda	30 oz.

(20) "A pulverized carbonaceous material mixed and incorporated with a saline solution."
(21) Sodium phosphate and tannin.
(22) 1 qt. water.
3 lb. whiting.
½ lb. soda (caustic).
½ lb. soap powder.
¼ lb. borax.

(23) Sodium amalgam	15 per cent
Tannin	10 per cent
Kerosene	10 per cent
Whale or seal oil to emulsify.	
Caustic soda	15 per cent
Dextrin	25 per cent
Sodium phosphate	15 per cent
Water	10 per cent

(24) $C_{10}H^8$,nophthalene) in gasoline or naphtha or other light hydrocarbon oil.

(25) Animal or vegetable charcoal, coal or lampblack in combination with caustic soda or soda ash.

TABLE III

COST OF CHEMICALS REQUIRED TO ACT ON ONE POUND OF EACH OF THE VARIOUS DETRIMENTAL SUBSTANCES IN WATER

To Act on One Pound of

	Lime, Ca O, \$0.63 lb.	Sodium carbonate, Na_2 CO_3, \$2.99 lb.	Caustic soda, Na OH, \$4.22 lb.	Tri-sodium phosphate, Na_3PO_4, 12 H_2O, \$4 lb.	Sodium fluoride, Na F, \$17 lb.	Barium hydrate, Ba $(OH)_2$, \$33.33 lb.	Barium carbonate, Ba CO_3, \$3.55 lb.	Barium chloride, Ba Cl_2, 2 H_2O, \$3.50 lb.	Borax, $Na_2B_4O_7$, 10 H_2O, \$8.25 lb.	Tannic acid, $C_{14}H_{10}O_9$, \$65 lb.
Calcium carbonate as bicarbonte, Ca CO_3	.35	3.17	3.38	10.12	14.28	57.06	.....	.....	31.52	418.60
Calcium sulphate, Ca SO_4	...	2.35	2.48	7.48	10.51	41.96	4.85	6.29	23.18	307.78
Calcium chloride, Ca Cl_2	...	2.88	3.04	9.13	12.85	51.46	.....	.....	28.39	377.13
Magnesium carbonate as bicarbonate, Mg CO_3	.42	3.77	4.02	12.06	17.00	67.72	.....	.....	.....	498.36
Magnesium sulphate, Mg SO_4	.29	2.66	2.81	8.44	11.90	47.43	5.50	7.13	.....	349.16
Magnesium chloride, Mg Cl_2	...	3.36	3.55	10.66	15.03	60.00	.....	.....	.....	440.64
Carbon dioxide, CO_2	.80	7.21	7.67	23.03	.....	129.82	.....	.....	.....	......
Sulphuric acid, H_2SO	.36	3.23	3.44	10.33	.....	57.99	6.73	8.72	.....	......
Hydrochloric acid, H Cl	.97	8.68	4.63	27.72	.....	81.43	9.05	.....	.....	......

Under price per lb., on this table, the materials in Table II have been recalculated to 100 per cent purity basis. All prices are shown in cents. Sodium silicate is not shown on this table on account not being able to secure satisfactory data in regard to percentages of Na_2 Si O_3 present.

In the preceding tables the items shown are the important points that should be considered in the use of boiler compounds.

Before going into the use of a boiler compound on a large scale, the composition of the compound should be ascertained, and its value in removing the scale and acid materials should be determined. The cost of the compound should be compared with the cost of treatment with lime and soda ash in a regular treating plant. The labor in applying the compound should also be compared with the labor of operating a regular treating plant.

TABLE II

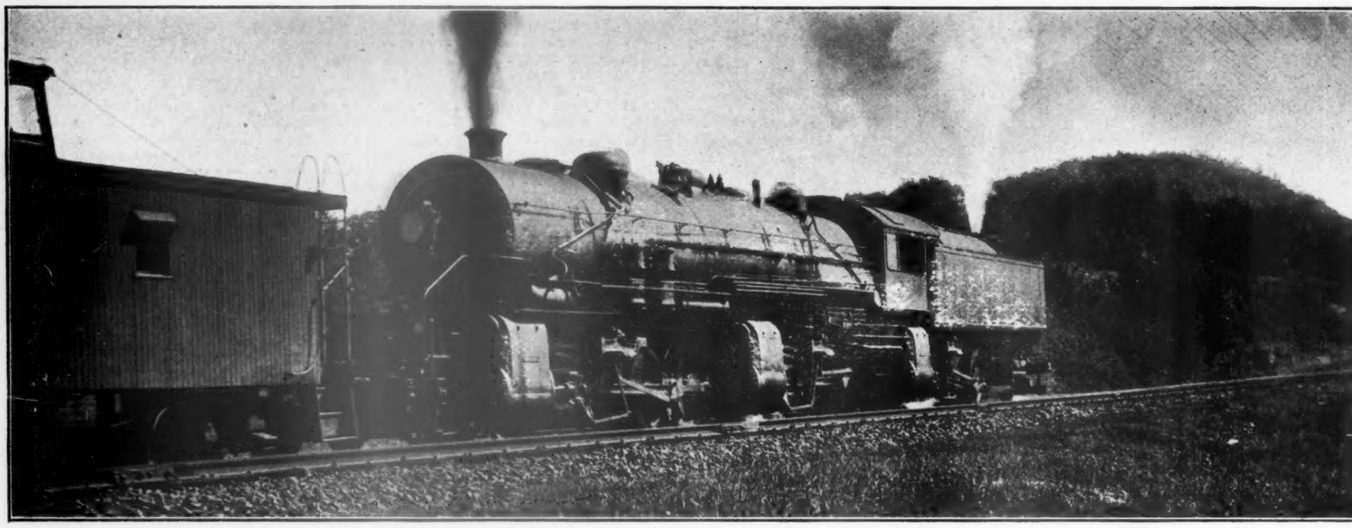
WHOLESALE PRICES OF CHEMICALS IN EFFECT JANUARY 1, 1919

Lime, 88 per cent	\$11.05 ton
Soda ash, 98 per cent	58.60 ton
Caustic soda, 76 per cent Na_2 O	4.15 cwt.
Sodium phosphate	.04 lb.
Sodium silicate, 49 deg. Baume	.02 lb.
Sodium fluoride	.17 lb.
Barium hydrate, 54 per cent	.18 lb.
Barium carbonate, 97 per cent	65.00 ton
Barium chloride	70.00 ton
Boras	.08¼ lb.
Tannic acid (commercial)	.65 lb.

In all cases lowest quotations are given.

It should also be remembered that when using a boiler compound, the only way in which the scale can be removed is by blowing down. Blowing down wastes water and steam which has been brought to boiler temperature at the expense of coal.

NO BOLSHEVISM THERE.—Railwaymen in Southern Italy sent a telegram to the prime minister offering to give the state an additional hour's work a day in order to increase the country's production.—*Great Western Railway Magazine.*



SCIENTIFIC DEVELOPMENT OF THE LOCOMOTIVE*

Factors Affecting the Cost of Maintenance and Operation Analyzed and Improvements Suggested

By JOHN E. MUHLFELD

MARKED progress has been made in the development of the steam locomotive as the result of superior engineering ability, and the results have in many respects been exceedingly effective. This progress, however, has been confined largely to an increase in size, weight, evaporating capacity and hauling power, and while the general use of superheaters and firebox baffle walls during the past ten years has substantially assisted in improving sustained boiler capacity and increasing thermal efficiency as well as in keeping the steam locomotive in advance of the electric locomotive, the opportunity for further improvement in thermal and machine efficiency and to reduce smoke, cinders, sparks and noise is untold.

The desiderata in a steam locomotive may be summed up as: a reasonable first cost; maximum capacity for the service within roadway weight, curvature and clearance requirements; ability to handle the heaviest gross tonnage practicable at the highest permissible speed; positive control of mechanical operation; economy as regards fuel and water consumption and repairs; minimum manual labor for road and terminal handling; construction of the least number of parts, and capacity to perform continuous mileage without failure.

Mr. Muhlfeld describes many radical innovations that are being incorporated in the design of a new freight locomotive and analyzes the defects of present types of construction.

Modern types of steam locomotives fulfill quite satisfactorily all of these requirements, with the exception of wastefulnes in fuel, water and steam consumption, as may be gathered from the fact that the thermal efficiencies now obtained are only from 50 to 65 per cent at the boiler, from 60 to 75 per cent for the combined boiler and superheater, and from 4 to 6 per cent at the drawbar. These as compared with thermal efficiencies of from 3 to 5 per cent at the drawbar of an electric locomotive, 18 to 19 per cent at the switchboard of a modern steam-electric central power station, 25 to 30 per cent for internal-combustion engines, and 40 to 45 per cent as claimed for the full range of from one-quarter to full load for combination internal-combustion and steam motors.

The increase in the first cost and in the cost for labor, fuel, material and supplies for operation and maintenance of the steam locomotive has been most marked during the past ten years, particularly since the war. It is now being operated and maintained by highly paid enginemen and mechanics, with high-priced materials and supplies, and the machine and its performance must be brought up to a more respectable basis of engineering efficiency if it is to be perpetuated.

The supporting data of this paper, which apply to the United States, present the reasons why the general improvement of the steam locomotive should embrace the following changes which are now being embodied in the construction of a new type of locomotive, the first of which it is planned to have in regular service in 1920: *a.* steam at a pressure of about 350 lb. to be employed, superheated about 300 deg. F.; *b,* improved boiler, furnace and front-end design and appliances; *c,* greater percentage of adhesive to total weight, and a lower factor of adhesion; *d,* more efficient methods of combustion; *e,* use of exhaust steam heater and flue-gas economizer for boiler feedwater; *f,* better steam distribution and utilization; *g,* reduced cylinder clearances and back pressure; *h,* lighter and properly balanced reciprocating and revolving parts; *i,* lower heat, frictional and wind-resistance losses; *j,* improved safety and time, fuel and labor-saving devices.

Reasons for Perpetuation of the Steam Locomotive

Much more has been said and written during the last few years about the electrification of the steam roads of the United States for the purpose of fuel and labor saving and conservation, but practically nothing has been set forth as to the possibilities to accomplish much greater results per dol-

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers. Owing to the length of Mr. Muhlfeld's paper, it is not possible to publish it in full in this issue. The sections dealing with the generation and utilization of steam will appear in next month's issue.

lar of investment and operating cost by a scientific development of the steam locomotive. As the average use of power at any considerable load factor is for only 8 hours per day, and as there is more or less irregularity in the demand, due to the small use on Sundays and holidays, the available water power would be used only about 2,400 out of possible 8,760 hours per annum, or about 27 per cent of the time, so that the remaining 73 per cent would be wasted. Therefore, where continuous water power is available it should be diverted to the special requirements of large and regular amounts, such as in electro-chemical and metallurgical processes, in order that this waste may be reduced to a minimum.

The methods at present employed for generating electric power from fuel in large modern central power stations represent from 18 to 19 per cent thermal efficiency, and as the investment cost for a steam plant is from one-third to one-quarter of that for a water-power development, the same total investment would produce from three to four times as much power from a steam plant as could be secured from a hydroelectric plant.

Complete electrification of some portions of the large transcontinental trunk lines has been effected, all of which are representative of progressive engineering skill, but reliable reports and statistics available have not proven the actual operating economies predicted, and with the present unsettled state of the electrical art numerous objections present themselves, among which may be noted: *a*, prohibitive capital and non-productive cost per mile for road, equipment and facilities; *b*, non-interchangeable equipment adaptable to certain electric zones only; *c*, entire operation dependent upon single power plants and transmission systems; *d*, widely varying load factors—dependent upon business conditions—requiring enormous outlay to meet uncertain peak movement and emergency conditions; *e*, complication and congestion of road and terminal trackage with transmission and contact lines; *f*, first cost from five to ten times, and operating cost from two to three times that of steam; *g*, liability for complete tie-ups due to storms, snow, sleet, rain and short-circuits.

Any general plan to electrify the steam roads to meet other than terminal and trunk-line congestion conditions, at an absurd cost, would mean lack of efficiency and prohibitive financing, which would result in bankruptcy for most of the railroads affected and in a further burden upon the public. In fact, it would be a source of real danger to the rehabilitation of these transportation systems, as to discard steam locomotives where coal or oil is available and can be burned with efficiency, comfort and economy, represents absolute waste.

Proposed Order of Development of the Steam Locomotive

The opportunity for steam locomotives to produce economy by increasing train loads, reducing transportation and mechanical delays and saving fuel and labor, is enormous.

The principal parts of a steam locomotive assembly are the boiler, engine, running gear, tender and special appliances, and the functioning of these parts in operation, jointly or independently, will involve particular factors that are capable of scientific development, viz.:

1 Design, Material and Workmanship.
2 Adhesive Weight, Tractive Power and Factor of Adhesion.
3 Tracking, Curving and Riding.
4 Boiler Feedwater.
5 Boiler-Feedwater Purifying.
6 Fuel.
7 Combustion.
8 Boiler-Water Circulation.
9 Heat Radiation, Convection and Conduction.
10 Steam Generation.
11 Steam-Pressure Increase.
12 Steam Superheating.
13 Steam Distribution and Utilization.
14 Waste-Heat Distribution and Utilization.
15 Friction and Resistance.
16 Acceleration.
17 Deceleration.
18 Lubrication.
19 Insulation.
20 Safety Appliances.
21 Special Appliances.
22 Power for Accessories.
23 Time Saving.
24 Fuel Saving.
25 Labor Saving.

The supporting data relating to the improvement of these factors are presented below:

Design, Material and Workmanship

Only by greater refinement in construction can requisite operating results be produced to offset the increased cost of equipment supplies and labor. Therefore the designing should now be done along more scientific lines through the substitution of boiler, cylinder and drawbar horsepower and drawbar pull calculations for tractive power; thermal efficiency for evaporation results; distributed for centralized thrusts, strains and stresses; light, high-grade alloy and high-carbon steels and other metals for heavy, low-grade plates, forgings and castings; and in the more general use of high-grade engineering practice in lieu of rule-of-thumb methods.

In the modern high capacity locomotive it is necessary that certain parts be made as light as possible. On the other hand, the items of fatigue and shock of metals due to continued vibrations and impact as well as of inherent combinations of weakening chemical and physical characteristics, are responsible for many sudden failures of staybolts, plates, springs, axles, crankpins, tires, piston and main rods, frames and like parts that are subject to reversal of stress or to hundreds of thousands of repeated and localized loads. As it has been found that the elastic limit is not necessarily representative of the fatigue strength, these factors require that further careful research and study be made for the purpose of determining upon a reliable quick test that will insure against unsuitable material entering into the construction.

The same degree of refinement applies equally to workmanship for construction and upkeep, which should be brought up to the same standard as obtains in other machinery that is producing more efficient and economical power for other modes of travel.

Adhesive Weight, Tractive Power and Factor of Adhesion

Adhesive Weight. In the ideal locomotive all of the weight is carried on the driving wheels for utilization as tractive power. The extended use of non-productive trailing wheels and the four-wheel leading truck has become an expensive fashion in that it has greatly reduced the percentage of total engine weight on drivers for adhesive purposes. For example, where a modern Mikado type locomotive will average 75 per cent adhesive to total engine weight, a modern Consolidation will run as high as 92 per cent, thereby utilizing much more of its weight to produce drawbar pull, hauling power and earning capacity.

Boiler design and weight distribution should be so correlated to the running gear as to make the use of trailer wheels unnecessary except where required by wheel load limitations, and with the more recent improvement in constant resistance leading truck designs any four-wheel arrangement, except for high-speed passenger service, should be entirely satisfactory.

Tractive Power. In calculating tractive power the usual practice is to use 85 per cent of the indicated boiler pressure in lb. per sq. in. for two and three-cylinder single expansion, and 52 per cent for two and four-cylinder compound engines. However, for a superheated steam locomotive the use of a higher percentage of the indicated boiler pressure should receive due consideration when making tonnage rating schedules before the train load is finally determined upon, as dynamometer tests have indicated that as high as 92 per cent for two-cylinder single expansion locomotives is permissible for train-loading purposes.

Factor of Adhesion. In the same way that the leading

and trailing truck type of locomotive has reduced the percentage of adhesive weight, so also has it increased the factor or ratio of adhesion, due to the "bridging effect" thus obtained over the driving wheels, tending to release the weight on the latter. Whereas many successful Consolidation types of locomotives are now operating with factors of adhesion of from 3.55 to 4.0, the Mikado types will usually range from 4.0 to 4.5. The co-efficient of static friction or adhesion between driving wheel tires and very dry, clean rails reaches a maximum of about 0.35, and for moist, muddy, greasy and frosty rails a minimum of from 0.15 to 0.20, giving factors ranging from 2.85 to 6.65.

In general, the factor of adhesion should be as low as practicable in order that the maximum power will always be available to start trains that can be easily handled when in motion and should about equal the ratio between the limiting friction in pounds and the weight on driving wheels in pounds, which for average dry rails is from 3.5 to 4.

Tracking, Curving and Riding

With the increased length, higher center of gravity, extended front and back overhang, and smaller proportion of spring-borne weight there have been many difficulties to overcome in order to maintain proper tracking, curving and riding qualities in locomotives of great power, and in the majority of cases these have been met with unusually satisfactory results.

Certain changes can be made, however, that will bring about a general betterment in the way of reduced rolling, oscillation, nosing and pounding, namely, reduced spread of cylinders; more uniform distribution and equalization of weight over driving and truck wheels; maximum permissible diameter of driving wheels; reduction in weight of revolving and reciprocating parts and counterbalance and proper distribution between wheels; improvement in constant-resistance lateral-motion devices; more uniform cylinder pressures when using steam and drifting; and greater refinement in control of end play, wheel and rail clearances, and tire-tread coning.

As the centrifugal power force of surplus counterbalance, the swinging movement of spring-borne weight and the rotative force on the crankpins are constantly changing in combination with speed and cut-off, the importance of giving particular attention to all of the foregoing cannot be overestimated.

Friction

Friction. Friction due to oscillation, concussion, rolling, wheel flanges and treads, journals, cylinders, valves, valve gear, crossheads, center and side bearings, coupler side play and the like absorbs a considerable percentage of the power developed by the steam.

Maximum machine efficiency, or ratio of drawbar to indicated horsepower, is usually obtained at speeds of from 25 to 50 miles per hour and ranges from 80 to 85 per cent, above which speeds, due to increased friction, it gradually decreases to about 70 per cent at 75 miles per hour. For example, with a locomotive developing about 2,000 hp. at a speed of 30 miles per hour, about 325 hp. would be lost in internal or machine friction.

During the past ten years the increased rigid wheelbase and axle loads, greater lateral rigidity, larger cylinders, valves and revolving and sliding bearings, substitution of grease for oil lubrication, and greater number of frictional parts, have tended to increase the machine friction and consequently the horsepower, drawbar pull, the steam and fuel losses.

All of these are factors that should receive proper consideration in new designs.

Resistance

Resistance. Other than the resistance resulting from machine friction, the locomotive is subject to those due to grades, curves, weather, wind and head air, which latter is more particularly affected by the general design. As the horsepower required to overcome front air pressure increases with the cube of the speed plus the resistance due to the "air in motion," reduction of transverse flat surfaces, smoothing off of projections, vestibuling of openings and use of general curves parallel to the natural flow of the air should be carefully considered in high speed locomotives, particularly in view of the high fuel consumption and machine friction and the relatively small proportion of drawbar pull available for hauling trains at high velocities.

While the complicated design of a steam locomotive, particularly as regards the application of its accessories, makes the use of relatively smooth outside surfaces generally impracticable, still much has been done along this line on some of the European railroads that can be adopted by us to good advantage.

Acceleration

As the train resistance increases and the drawbar pull of the locomotive decreases due to speed, acceleration, rapidly becomes a diminishing quantity. Therefore in order to expedite train movement, locomotives should be designed and adjusted so as to permit of the highest possible rate of acceleration in the shortest distance after starting, in order that the maximum desired running speeds can be reached in the minimum of time during which the greatest evaporating capacity of the boiler is available. In locomotives designed with trailer wheels a great deal of otherwise available adhesive power, particularly for starting and acceleration purposes, is being wasted and the utilization of this lost adhesive weight by the elimination of trailer wheels, or by the application of an independent means of power for their propulsion, would accomplish a great deal in the way of starting and accelerating trains to speeds of from 15 to 20 miles per hour.

Deceleration

Deceleration is as much a factor in expediting train movements as acceleration, particularly with long and heavy trains and grades, and improved brake-shoe design, material, flexibility and bearing area in combination with clasp types of brakes for all wheels would do much toward providing greater stopping control over large and high speed steam locomotives and thereby avoid the necessity for resorting to the use of the engine cylinder back pressure to produce adequate braking power without liability for skidding and flattening the driving wheels.

Lubrication

Valve Oil. The usual method of feeding valve oil is through a steam-condensing lubricator. However, this method gives an irregular feed of oil to engine valves and cylinders if no change is made in the adjustment of the sight feeds when the locomotive is at rest, working with a light or a full throttle, or drifting. With high steam pressures and superheat a suitable automatic force- food lubricator, located near the steam chests, with individual feeds to engine valves and cylinders and adjusted to insure a positive and uniform feed of 50 per cent of the oil to each of the valves and cylinders at all times when the locomotive is moving, will unquestionably give better results.

Piston and valve rods equipped with a suitable aluminum-zinc lead alloy metallic packing should not require lubricators or swabs except on roads where a high percentage of drifting obtains.

Superheat valve oil is unnecessary, as carbonization of oil is due to air admission to engine valve chests and cylinders when their temperature is greater than the finish point of the oil used and is also aggravated by the induction of gas and cinders through the exhaust nozzle.

The results of tests made to determine the respective coefficients of friction of oil and grease-lubricated journals

show the former to be about 0.02 and the latter about 0.03 Therefore, while the internal or machine friction of the modern locomotive has been considerably increased due to the use of solid lubricants in combination with relatively high bearing pressures, and the wear on these frictional surfaces has been materially increased, grease has nevertheless protected bearings that would otherwise have heated, and its use will no doubt be continued until a satisfactory automatic force-feed method of oil lubrication is devised.

Machinery Oil. This is the ideal lubricant for wearing parts not subjected to excessive concentrated pressures and temperatures, and should be employed wherever a better distribution of the work, proportion of parts, or method of application will permit of its use. There is opportunity for much to be accomplished in the development of a more satisfactory and automatic means for its application.

Insulation

The loss of heat through radiation justifies a considerable expenditure for its prevention, and the most practical method for reducing this waste is to first design and locate the heat-transmitting parts so that they will be the least exposed to the surrounding atmosphere and to then make use of a good non-conducting lagging, properly applied.

With the available non-corrosive heat-insulating materials that can now be readily molded into sectional blocks to any form and size desired for ready application and removal, and which will withstand the disintegrating effects of heat, vibrations and concussions incident to modern locomotive operation, there is no good reason why boilers, fireboxes, steam pipes, valve chests, cylinders and heads, air pumps and other heat-radiating accessories or parts should be left exposed in the way they generally are, with the resultant steam and fuel losses.

Safety Appliances

While the annual reports of the Interstate Commerce Commission on personal injury accidents chargeable to locomotive equipment indicate that considerable remains to be done to improve safety with respect to boiler fireboxes, staybolts, flues, tubes, plugs, studs, blow-off cocks, water gages and grate shakers; injectors and connections; lubricators; squirt hose; reverse gears; main and side rods, and draft gear, a great deal in this direction has been accomplished during the past seven years through the co-operation of the railroads and the locomotive and equipment builders with the Interstate Commerce Commission inspectors.

Special Appliances

Tender Trucks. The present use of staggered instead of square rail joints in track laying results in considerable vibration and surging of tenders when first-class track surface and alignment are wanting. This derailing action necessitates the use of a flexible type of tender truck, such as will make it possible for each wheel to always follow and remain on the rail with which it is in contact without regard to any other wheel in the truck, if liability to derailment is to be avoided.

Truck Wheels. According to the reports of the Interstate Commerce Commission there were 954 derailments on the steam railroads during the year 1917 that were due to broken flanges and broken and burst wheels; these caused damage to railroad property amounting to $1,132,030, and resulted in the killing of 16 and the injury of 72 persons. While these reports apply to both locomotives and cars, still they indicate the urgency for improvement.

With increasing wheel loads and speeds and higher and longer braking pressures the chilled-iron and cast and forged steel wheels must not only be of the best design, material and construction to meet the most severe requirements with a proper degree of safety, but the weights should be reduced to an economical maintenance and operating basis. Chilled iron and forged steel wheels have become particularly notorious with respect to non-productive deadweight resulting from unsuitable or surplus metal, or both, and necessity will now demand an early betterment.

Mechanical Stokers. Reports indicate that stoker-fired locomotives burn from 10 to 40 per cent more coal than those hand fired, which includes the additional coal used for operating the stoker equipment, and that the cost for stoker repairs ranges from 2 to 4 cents per locomotive mile. Also that failures occur due to broken stoker parts, foreign matter in coal and wet coal. The kind and preparation of fuel are also items of importance, particularly as relating to low-volatile bituminous and anthracite coal.

It is doubtful whether any considerable progress in efficiency or economy will be made in the stoker firing of locomotives in combination with the limitations now imposed by burning coal on grates or in retorts with forced draft, and this is a matter of the greatest concern in the economic development of the steam locomotive.

Air Compressors. Compressed air is one of the most expensive mediums for producing power, particularly when the compressing is done by the single-stage system which is still in use on the majority of locomotives. As the steam is used at long cut-off and the heat of compression is dissipated and represents lost work, an average of from 70 to 85 lb. of saturated steam at 200 lb. pressure is required per 100 cu. ft. of free air compressed to from 100 to 130 lb. pressure.

For air pressures of 100 lb. and over a cross-compound steam and two-stage air compressor with intercooler between the air cylinders should be used. This will easily give an equivalent compressed-air production on from one-third to one-fourth of the steam consumption which results can be further improved by the use of superheated steam.

Main-Driving-Axle Boxes. These are the seat of one of the serious deficiencies in locomotives of great power. As any change in the alignment of the main driving axle or an accumulation of lost motion therein immediately affects the movement of the directly or indirectly connected main and inside rods, valves and pistons, it is most important that this axle be kept in close adjustment at all times. Increasing the length of driving boxes and the various means devised for applying and adjusting the crown bearings, hub plates and shoes and wedges have not yet produced the required result, and considerable opportunity for improvement still remains.

Lateral-Motion Devices. Restricting the lateral movement over leading and trailing truck and driving wheels as well as in tender trucks has been responsible for many derailments and much wheel-flange and rail resistance and wear, particularly with modern designs of locomotives of long wheelbase and high center of gravity. Promising results have obtained from the development of constant-resistance lateral-motion devices, but further improvement is needed along these same lines to meet the more extended rigid-wheelbase conditions.

Throttle Valves. These should be removed from the boiler where they are now an obstruction to making boiler inspections and are inaccessible for inspection, adjustments and repairs.

Power for Accessories

The steam locomotive must not only produce superheated steam for the development of drawbar pull, but also supply saturated steam to various accessories of its own and for train operation. Not only has the use of compressed air been found to be most expensive for the working of these accessories, but the reserve supply for train braking has been frequently drawn upon for their operation. As power reverse gears, fire doors, water scoops, coal pushers, ashpan doors and like devices can be equipped for steam operation, such substitution offers possibilities for less drain on the boiler and much needed economy in the cost for this auxiliary power production. Moreover, as all of this power for accessories is produced by saturated steam, some means for sub-

stituting the use of superheated-steam for those purposes where it is more suitable and economical should be given due consideration.

Time Saving

The principal time-saving factors other than speed reductions and stops necessary to take on and set off business and to meet roadway, train-despatching and operating requirements, may be stated as: *a*, acceleration; *b*, deceleration; *c*, mechanical road delays; *d*, mechanical terminal delays; *e*, fueling; *f*, watering.

Acceleration and Deceleration. Much time is to be gained in quickening the starting and stopping of locomotives. Any engineer who has noted the length of time usually taken to get a passenger, freight or switching locomotive, either light or loaded, under headway and to reduce the speed for a stop, will appreciate what this may amount to.

Mechanical Road Delays. These may be classed as due to engine, fuel, water and man causes.

With the adaptation of locomotives best suited for regional requirements and with proper improvements in design, material, construction, inspection, testing and upkeep, "engine causes" can practically be eliminated.

Through the installation of modern fuel-preparing facilities, provision for adequate tender capacity, adaptation of locomotives to utilize the most inferior and cheapest fuels available, use of simplified manual means of firing, and particularly by reducing the consumption required per boiler horsepower developed, the "fuel causes" can be substantially reduced.

The proper systems and time for washing out boilers and the supplying of suitable, treated if necessary, boiler water to adequate tender tanks will dispose of "water causes."

"Man causes" can best be avoided through the employment of competent men, the inauguration of proper systems for education and instruction, and by equipping locomotives so that they will require the least amount of arduous work.

Mechanical Terminal Delays. These are due principally to sanding, ashpan and fire cleaning, fire building, boiler washing, firebox, flue and smokebox cleaning, inspection, testing, machinery cleaning and repairs. Of these delays those due to ashpan, fire, firebox, flue and smokebox cleaning are the most prolonged and non-productive and can be reduced only by improved methods of firing, reduced fuel consumption per unit of work performed, and substitution of mechanical appliances for arduous labor, so that upon arrival at terminals locomotives can be run directly into the enginehouse instead of being held outside for this class of work and delaying upkeep attention.

Fueling. Many facilities for fueling locomotives, either with coal or oil, are obsolete, inadequate and uneconomical. Fuel should be prepared ready for firing before being placed on tenders, and with modern facilities practically no time should be lost in supplying, either on the road or at terminals.

Fuel Saving

The problem of locomotive fuel saving has never received more intelligent thought and attention from a supervising standpoint than during the past two years. This has been due to the war-time necessity for the conservation of both the fuel and the labor required for its production and to the fuel cost reflecting a constantly increasing percentage of the total expense for railroad operation.

While the furnishing of coal or oil of a proper kind and preparation) by an intelligent, trained and careful fireman to a locomotive in good working order and properly operated should result in effective and economical performance, the vast difference in the amount of fuel actually used by different train despatchers, engineers, firemen and locomotives to produce the same ton-mile movement under like transportation conditions indicates the necessity for reducing the amount of fuel to be fired per ton-mile by effective mechanical means and methods instead of depending upon the directly involved and responsible human element for equivalent results.

There is no questioning the fact that avoidable low boiler and mean-effective cylinder pressures, saturated steam, indifferent boiler circulation, excessive firebox draft, clogged grates and boiler and superheated tubes, forced combustion, high smokebox temperatures, unnecessary non-adhesive weight and generally indifferent steam generation, distribution and utilization factors, for which the engineer and fireman are not responsible, have more to do with high fuel and water rates than those factors within their control. Therefore the proper procedure, particularly in view of the relatively small increase in cost for the improved locomotive equipment as compared with the total locomotive cost and the reduced expense for its upkeep and operation, is to design and equip the modern steam locomotive so that it will more fully utilize the thermal heat value of the fuel and not be so dependent upon the manual control to bring the fuel used for productive work within the proper limitations.

Making initial capital and continual upkeep and operating expenditures in order to provide well-known inefficient and uneconomical mechanical means for handling, firing and wasting greater quantities of fuel than are within the easy range of one-man hand firing, in preference to diverting an equivalent amount of money for capacity increasing and fuel and water-saving appliances, represents a policy that is not at all consistent with existing and future labor and fuel costs if the railroads are to be continued on an investment basis.

Labor Saving

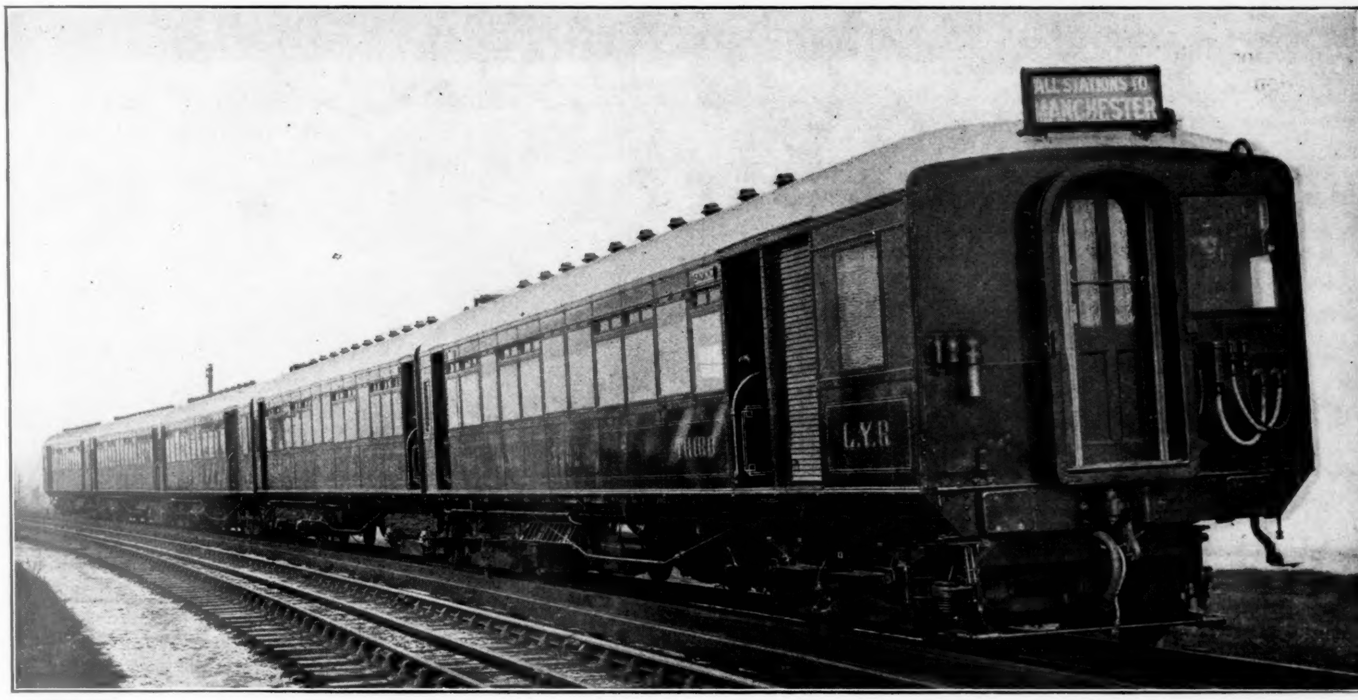
The labor now required for the upkeep, terminal handling and operation of the steam locomotive is divided into three classes, i. e., shop and enginehouse men, hostlers, cleaners and supply men, and enginemen.

The item of maintenance is distributed between general and running inspection, testing and repairs and is taken care of at the shops and enginehouses, respectively. During the past fifteen years a great deal of attention has been given in the planning of these facilities to provide labor-saving tools and machinery for dismantling, repairing and assembling locomotives and appurtenances, and there are today many conspicuous examples of modern railroad shops and enginehouses, even though many more are needed.

Great progress has been made in the establishing of adequate and suitable terminal handling, cleaning and supplying facilities which now include power-operated coal, sand and ash handling plants and turntables, high capacity water cranes, hot water boiler washing and locomotive cleaning systems, steam and compressed air stack and flue blowers and similar appliances. The cleaning and dumping of fires, ashpans and front ends and the rebuilding of fires is, with the increasing size of locomotives and the use of inferior coal, becoming a matter of great concern, delay and expense in the terminal handling, particularly during congested traffic and cold-weather periods, and a satisfactory solution of this problem still remains to be provided.

In the operation of locomotives the hours of service law established the general practice of pooling locomotives and crews, which system until that time had been adopted by only a few of the railroads. The divorcing of the engineers and firemen from regularly assigned locomotives, in combination with the increasing size of the latter, resulted in relieving the enginemen of work which was transferred to the enginehouse forces. This change, in combination with the more extended use of power-operated auxiliaries, has practically eliminated arduous manual operation on locomotives of great power.

The mechanical requirements and status of the engineer and fireman on the large steam locomotive having been substantially changed, there should now be a resulting higher standard of operation, efficiency and economy.



A Five Car Train on the Manchester-Bury Line

All-Metal Electric Multiple Unit Cars

The Lancashire & Yorkshire, England, Built During the War Interesting Equipment for Its Manchester-Bury Line

BY ROBERT E. THAYER
European Editor of the Railway Mechanical Engineer

The Lancashire & Yorkshire Railway was the first main line railway in Great Britain to adopt electric traction for its suburban steam service. Its first project was that of converting the Liverpool-Southport line, and later the line from Sandhills Junction to Ormskirk, the two projects involving 38 miles of track with an equivalent of 80 miles of single track, including sidings. The Liverpool-Southport line was opened to traffic in March, 1904. The multiple unit system of train control was adopted for this line with two 150 hp. motors on each truck, operating at 600 volts direct current, the power generated being 3-phase, 25 cycles alternating current at 7,500 volts.

Interior of First Class Smoking Compartment

This electrification scheme has met with great success. Passenger business has been constantly on the increase ever since the line was put into operation. Whereas there were four lines required in certain parts of this electrified line for steam service, under electric service two lines are sufficient to handle the traffic, although the frequency of trains has been more than doubled. In this way the widening and laying of additional lines through an extensive territory, which would have been required had steam working been retained, has been eliminated.

On the Liverpool-Southport line, which extends to Crossens, there are 14 intermediate stations which lie at an average distance of less than one mile apart on the southernmost portion and are more widely separated on the northern portion. There were about 36 trains a day in each direction between Liverpool and Southport under steam operation. This number has been increased to 70 under electric operation. The total train mileage per day under steam operation was about 1,900. This has been increased to 3,500. The running time from Liverpool to Southport, which was 54 minutes under steam operation, has been decreased to 37 minutes. The express service between Liverpool and Southport has been increased from four trains per day to ten.

During the first year of the electrification of this line 14 per cent more people were carried, with a reduction of from 78,393 tons to 69,160 tons in the total weight of rolling stock moved per day.

It was the excellent results obtained from this service that

lead to the electrification of the Manchester-Bury section of **that** same road, which was opened for service in February, **1916.** This line runs from Manchester via Prestwich to **Bury,** and from thence to Holcombe Brook, which is 13¼ miles from Manchester. The line has rather heavy grades

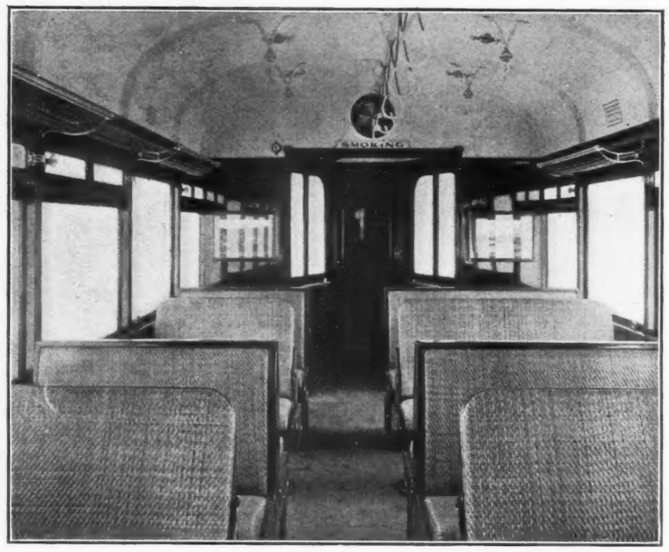
End View of Trailer Car

with several grades over 1 per cent and three of 2 per cent **or over.** The heaviest grade is 2.4 per cent for a little less **than a mile.** There are 14 intermediate stations on this line **between** Manchester and Holcombe Brook. As in the case

Lancashire & Yorkshire Motor Car

of the Liverpool-Southport line, this line uses the multiple **unit train** control system, but the driving current is 1,200 **volts** direct current instead of 600, and the cars are equipped **with** four 200 hp. motors, as the grades on the Manchester-**Bury** line are much heavier than on the Liverpool-Southport line. As in the case of the Liverpool-Southport line, the number of trains on this new line has been greatly increased.

Profiting by the experience obtained on the Lancashire-Southport electrification, a new design of motor car and trailer was developed for this new project. On account of the heavy gradients, and further, to permit of as rapid acceleration as possible due to the large number of stations on the line, a careful study was made to make these cars as light as possible and still retain sufficient strength to meet

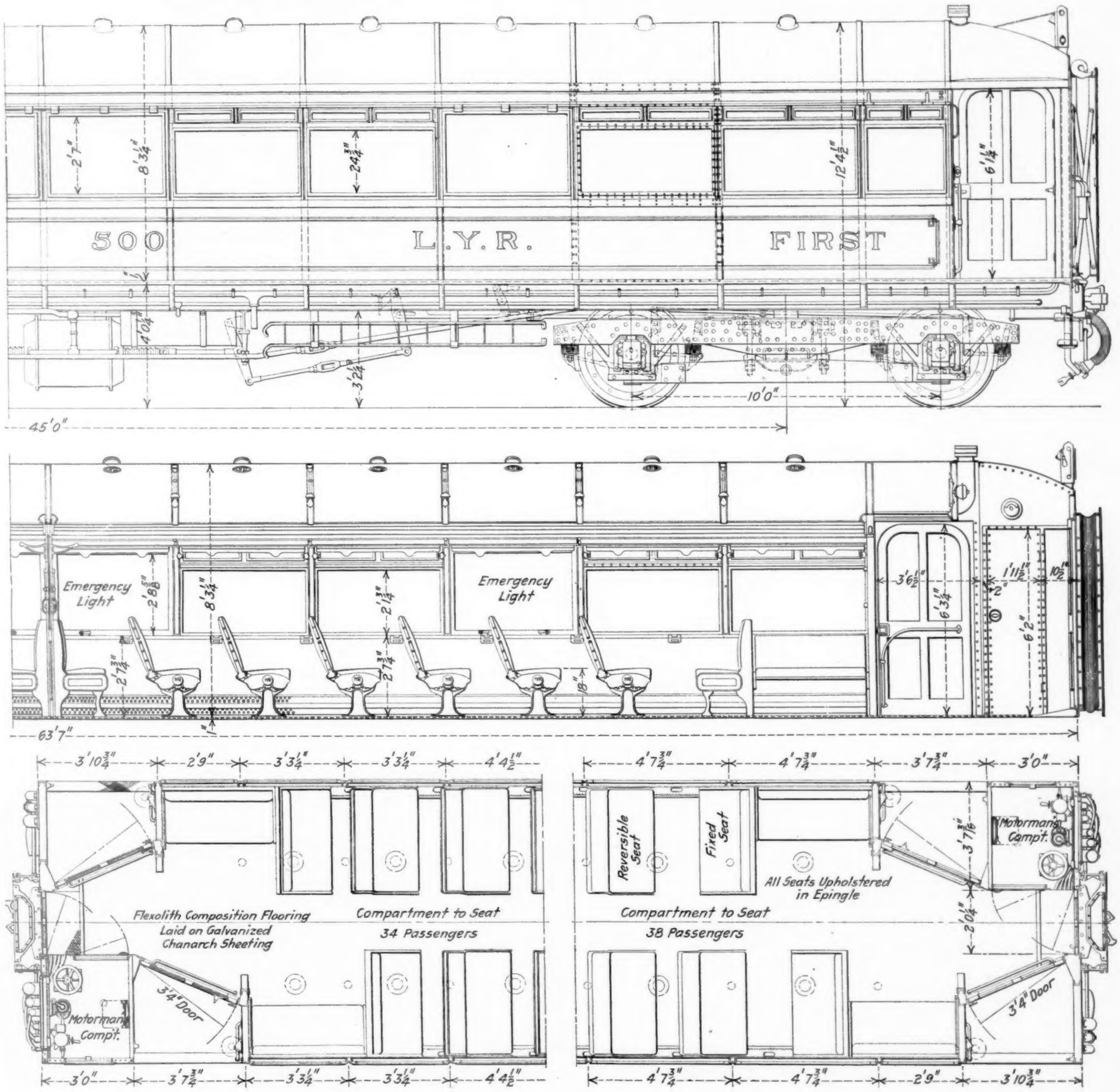


Interior of Third Class Smoking Compartment

all service conditions. Whereas the Liverpool-Southport cars are built of wood and metal, the new cars are built entirely of metal, alloy steels and aluminum being used to a considerable extent in an endeavor to keep the weight down. By using aluminum instead of steel plate, the weight of the cars has been reduced 1,623 lb. These cars are the first all-metal cars to be built for main-line service in Great Britain. Forty-six of them were built three years ago at the railway shops of the Lancashire & Yorkshire with the same force of men that had previously been used in the construction of the wooden cars, and no difficulty was experienced in adapting these men to the new materials involved in the

construction of the all-metal cars. These cars are divided into three classes—the motor car, which is always third class and is provided with a baggage department, and first and third-class trailers.

Contrary to the usual British practice of compartment arrangement, these cars were built with the open aisle similar to American practice and in accordance with the design used on the Liverpool-Southport line. In commenting on this arrangement Sir John A. F. Aspinall (general manager of the road at the time the electrification was adopted) stated in his presidential address before the Institution of Mechanical Engineers that with this arrangement the trains can be handled at stations much more quickly than with the compartment coaches having the side doors. "The most crowded cars are always emptied during rush hours in about 50 seconds at terminal stations, while intermediate stops only require 15 seconds to pick up and set down passengers." He also said, in favor of this arrangement, that greater strength can be obtained with such construction than where the side doors are used, and, in fact, in the design of these cars the side framing has been calculated in as a supporting structure.



Plan and Side Elevations of First Class Trailer Car

Comparison of Car Weights

The motor cars weigh unloaded 120,960 lb. These cars carry third-class passengers and have a baggage compartment. They have a seating capacity for 74 passengers, which gives a total unloaded weight per passenger seat of 1,634 lb. This compares with 2,206 lb., the weight per passenger of similar sized motor cars of composite construction.

The third-class trailer cars, which are provided with motormen's compartments on each end, but which carry no baggage, have an unloaded weight of 64,960 lb. These have a seating capacity for 95 passengers, which gives an unloaded weight per passenger seat of 683.7 lb. The third-class cars are provided with seating space for five people across the car—that is, three passengers on one large seat on one side of the aisle and two passengers on the other.

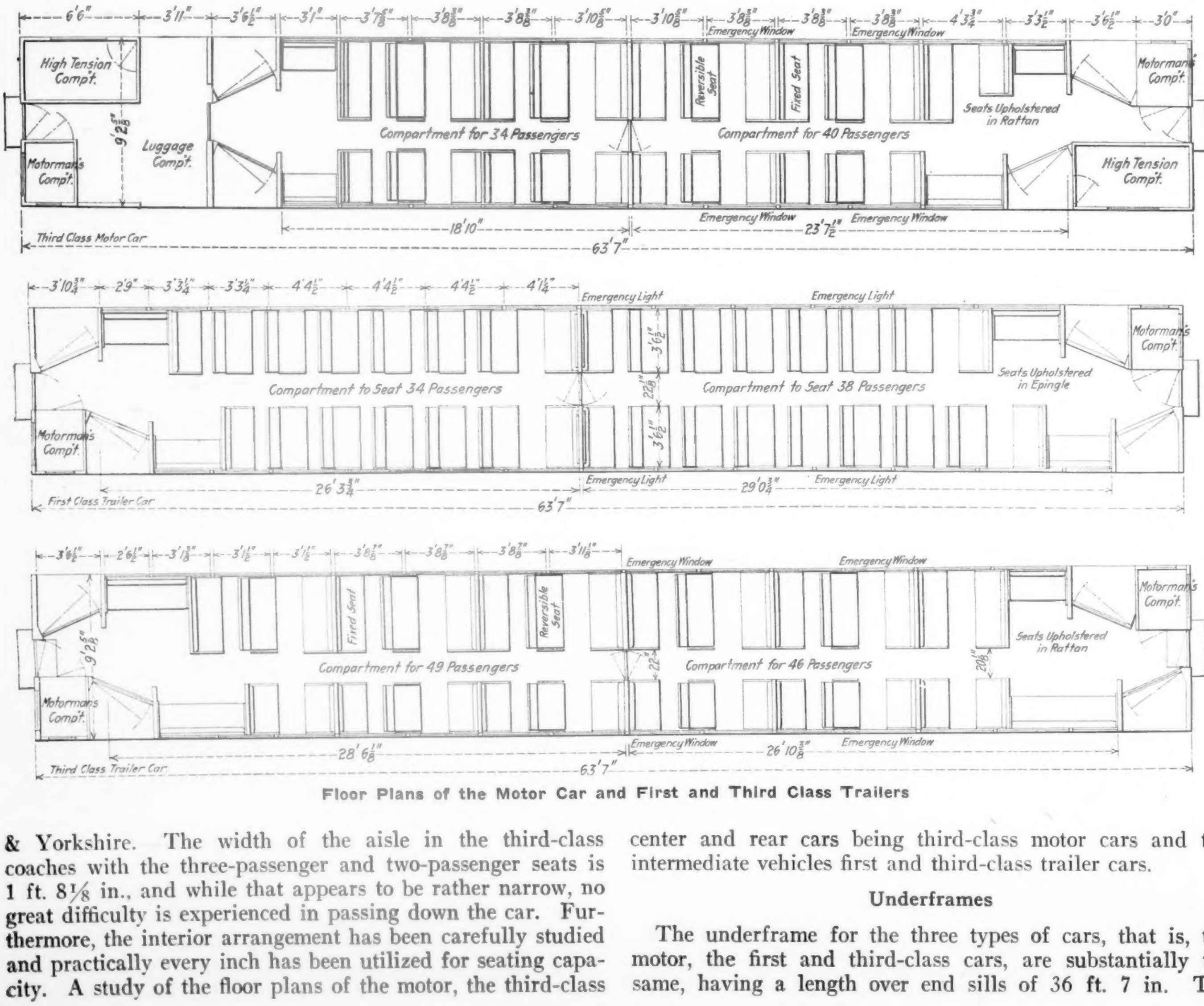
In the table is given a comparison of the principal dimen-

sions of the all-metal cars with the composite cars in use on the Liverpool-Southport line and with the all-steel cars in use on the Long Island in the United States. Comparing these trailer cars with those in use on the Long Island Railway, it will be seen that, whereas the Long Island cars are practically the same length, they have a width inside the body of 9 ft. 4½ in. as compared with 8 ft. 11½ in. on the Lancashire & Yorkshire, and they have a seating capacity for 80 passengers as compared with 95 on the Lancashire & Yorkshire cars. The Long Island cars weigh 63,100 lb. or 1,860 lb. less than the Lancashire & Yorkshire cars, but on account of the seating capacity, due to the fact that the seats provide for only two passengers, the weight of the car per seat is higher, being 788 lb. as against 683.7 lb. for the Lancashire & Yorkshire. The width of the aisle in the third-class coaches with the three-passenger and two-passenger seats is 1 ft. 8⅛ in., and while that appears to be rather narrow, no great difficulty is experienced in passing down the car. Furthermore, the interior arrangement has been carefully studied and practically every inch has been utilized for seating capacity. A study of the floor plans of the motor, the third-class and first-class trailers gives an indication of this. In comparing the all-metal trailer cars with those in use on the Liverpool-Southport line, it is to be mentioned that the latter cars have a motorman's compartment on one end only and that the Manchester-Bury all-metal trailer cars have underframes of sufficient strength to permit of motor trucks being used. In addition, more brake work is included on the all-metal cars. It has been calculated that these features account for 2,512 lb. of the total weight, which should be deducted when making a comparison. This would make the weight per passenger seat 643.7 lb. for the all-metal car, instead of 683 lb. as shown.

COMPARATIVE TABLE OF CAR DIMENSIONS

	Manchester-Bury M. U. C.	Liverpool-Southport M. U. C.	Long Island Trailer	Manchester-Bury Trailer	Liverpool-Southport Trailer
Length over all	63 ft. 7 in.	60 ft.	62 ft. 9¾ in.	63 ft. 7 in.	63 ft. 7 in.
Width over body	9 ft. 4 in.	10 ft.	9 ft. 9¾ in.	9 ft. 4 in.	10 ft.
Height of car inside, floor to roof	8 ft. 3¼ in.	8 ft. 0½ in.	....	8 ft. 3¼ in.	8 ft. 3¼ in.
Height from rail to top of floor	4 ft. 1¼ in.	4 ft. 4¼ in.	4 ft. 4⅝ in.	4 ft. 1¼ in.	4 ft. 4¼ in.
Height from rail to top of roof	12 ft. 4½ in.	12 ft. 7⅞ in.	13 ft.	12 ft. 4½ in.	12 ft. 7⅞ in.
Center of trucks	45 ft.	40 ft. 6 in.	39 ft. 9 in.	45 ft.	45 ft.
Wheelbase of trucks	9 ft.	8 ft.	6 ft. 4 in.	10 ft.	10 ft.
Type of roof	Clerestory	Clerestory	....	Elliptical	Elliptical
Number of passenger seats	74	68	80	95	97
Weight of two trucks complete	62,719 lb.	53,150 lb.	18,000 lb.	22,456 lb.	22,456 lb.
Weight of car unloaded	120,960 lb.	114,240 lb.	63,100 lb.	64,960 lb.	61,768 lb.
Weight per seat	1,634 lb.	1,680 lb.	788 lb.	683.7 lb.	636.7 lb.

The make-up of the standard train which operates on the multiple unit control system consists of five cars, the leading, center and rear cars being third-class motor cars and the intermediate vehicles first and third-class trailer cars.

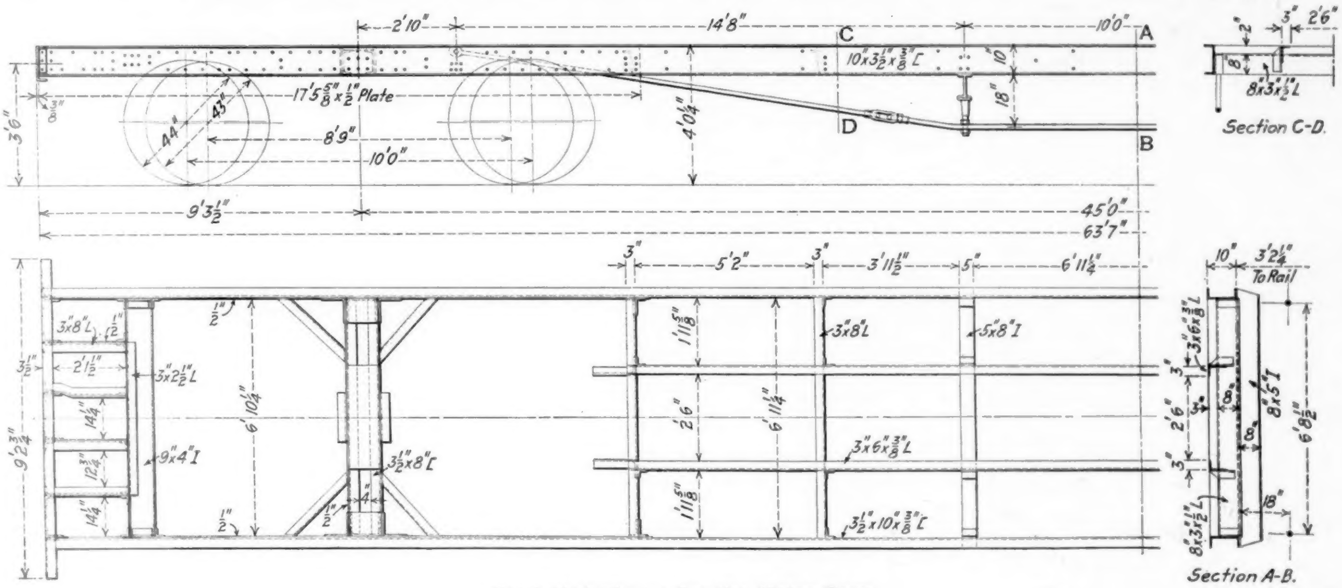


Floor Plans of the Motor Car and First and Third Class Trailers

Underframes

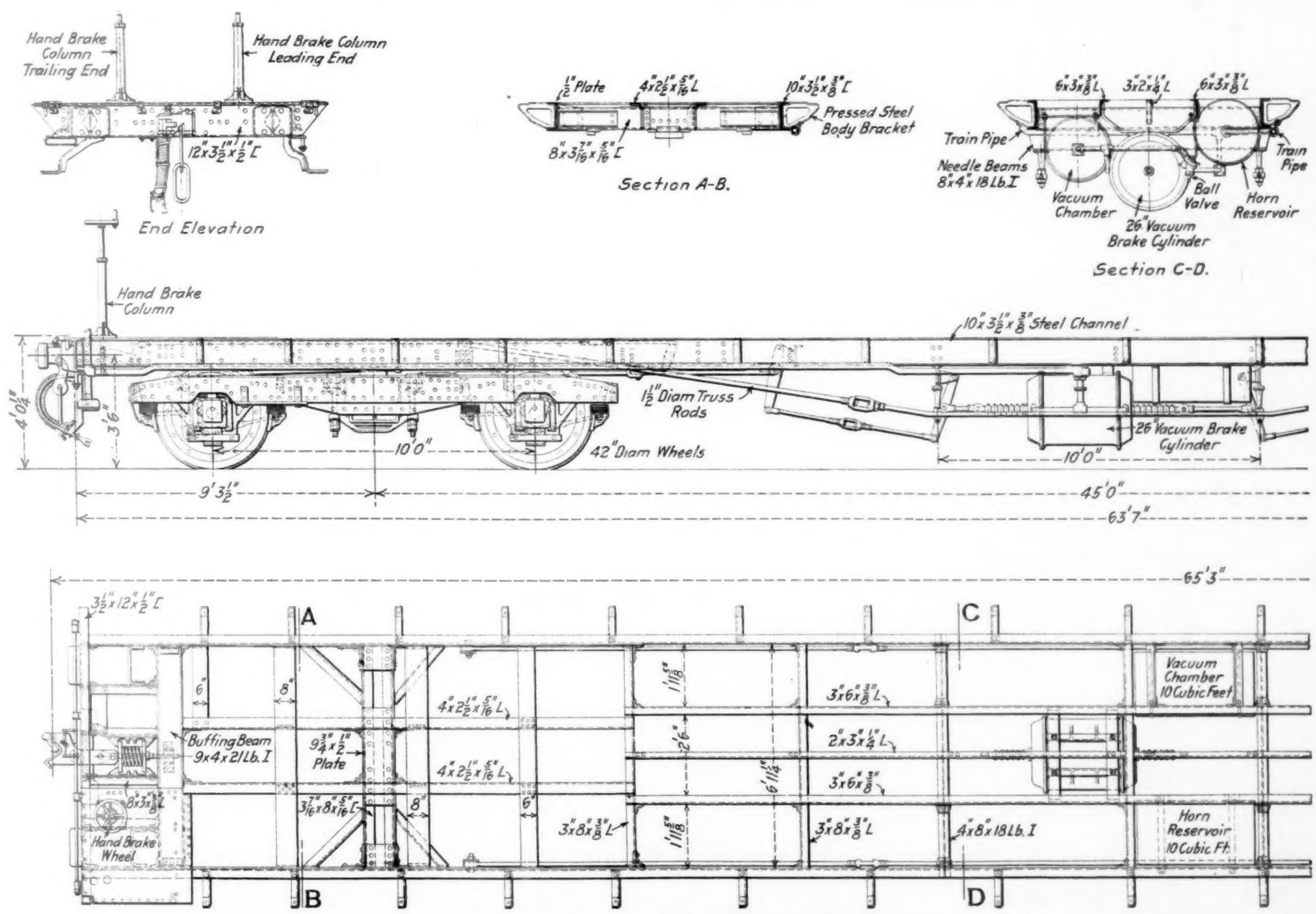
The underframe for the three types of cars, that is, the motor, the first and third-class cars, are substantially the same, having a length over end sills of 36 ft. 7 in. The

side sills are made up of $3\frac{1}{2}$-in. by 10-in. by $\frac{3}{8}$-in. channels. The side sills, however, are further reinforced at the ends by a $\frac{1}{2}$-in. plate riveted to the side sill, which extends



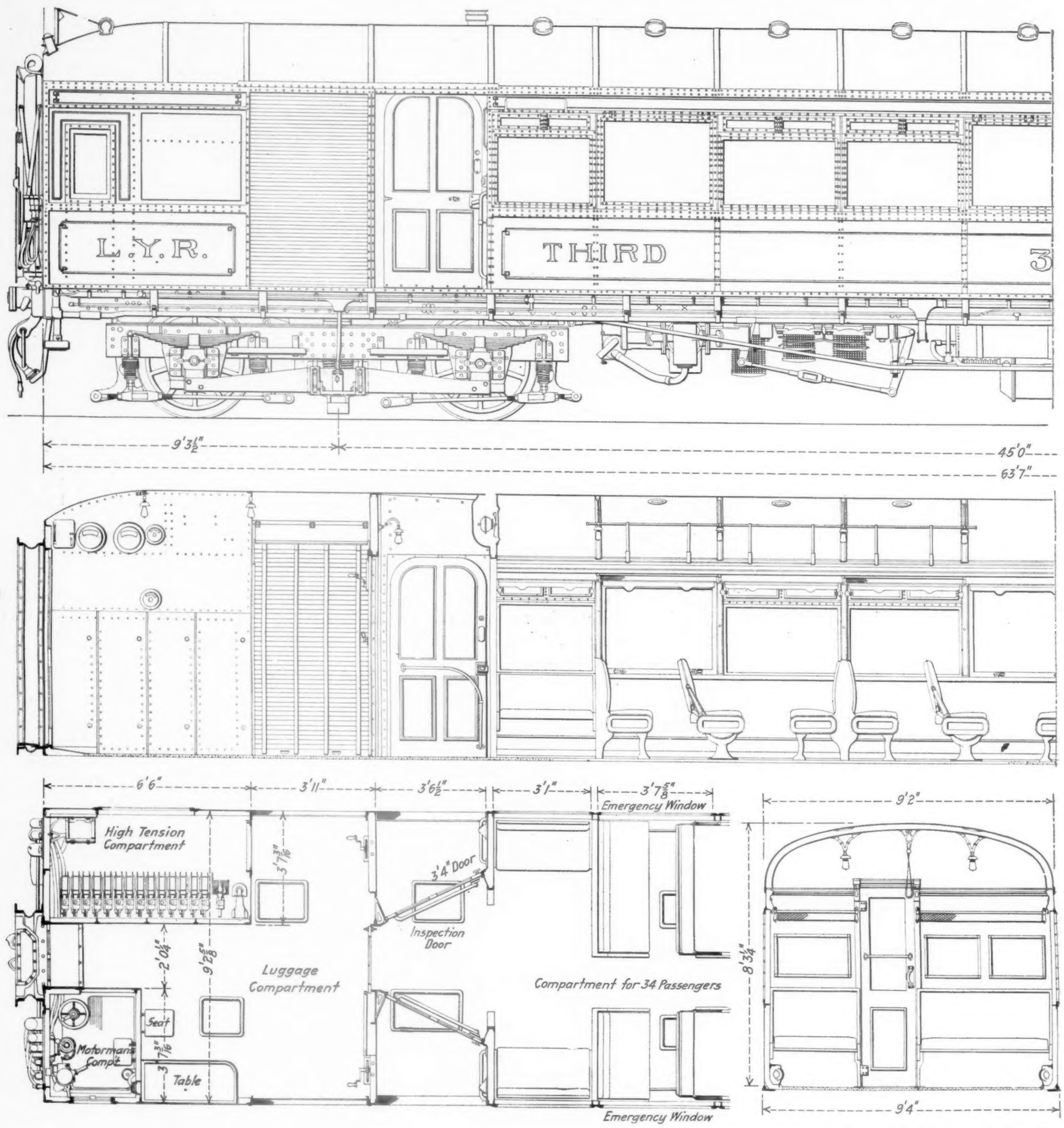
Steel Underframe for the Motor Cars

17 ft. $5\frac{5}{8}$ in. back of the end sill. The crossbearers are 3-in. by 8-in. alloy steel angles, and the intermediate floor sills are 3-in. by 6-in. by $\frac{3}{8}$-in. angles. These are set flush

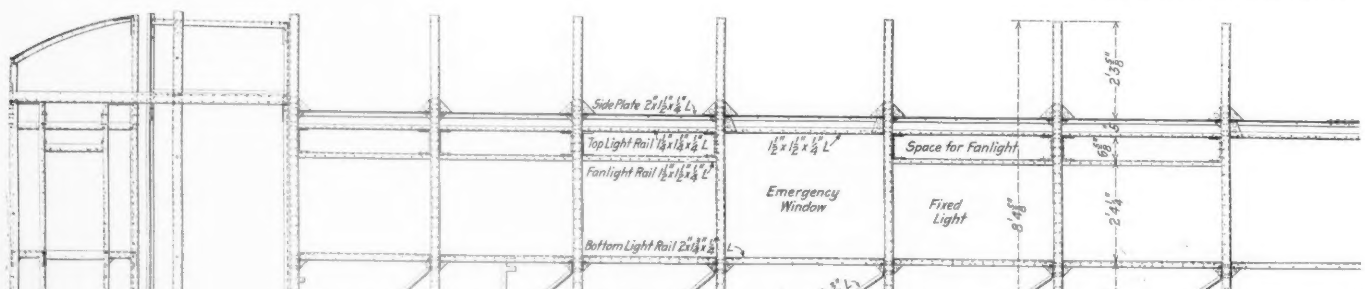


Steel Underframe for Third Class Trailer Car

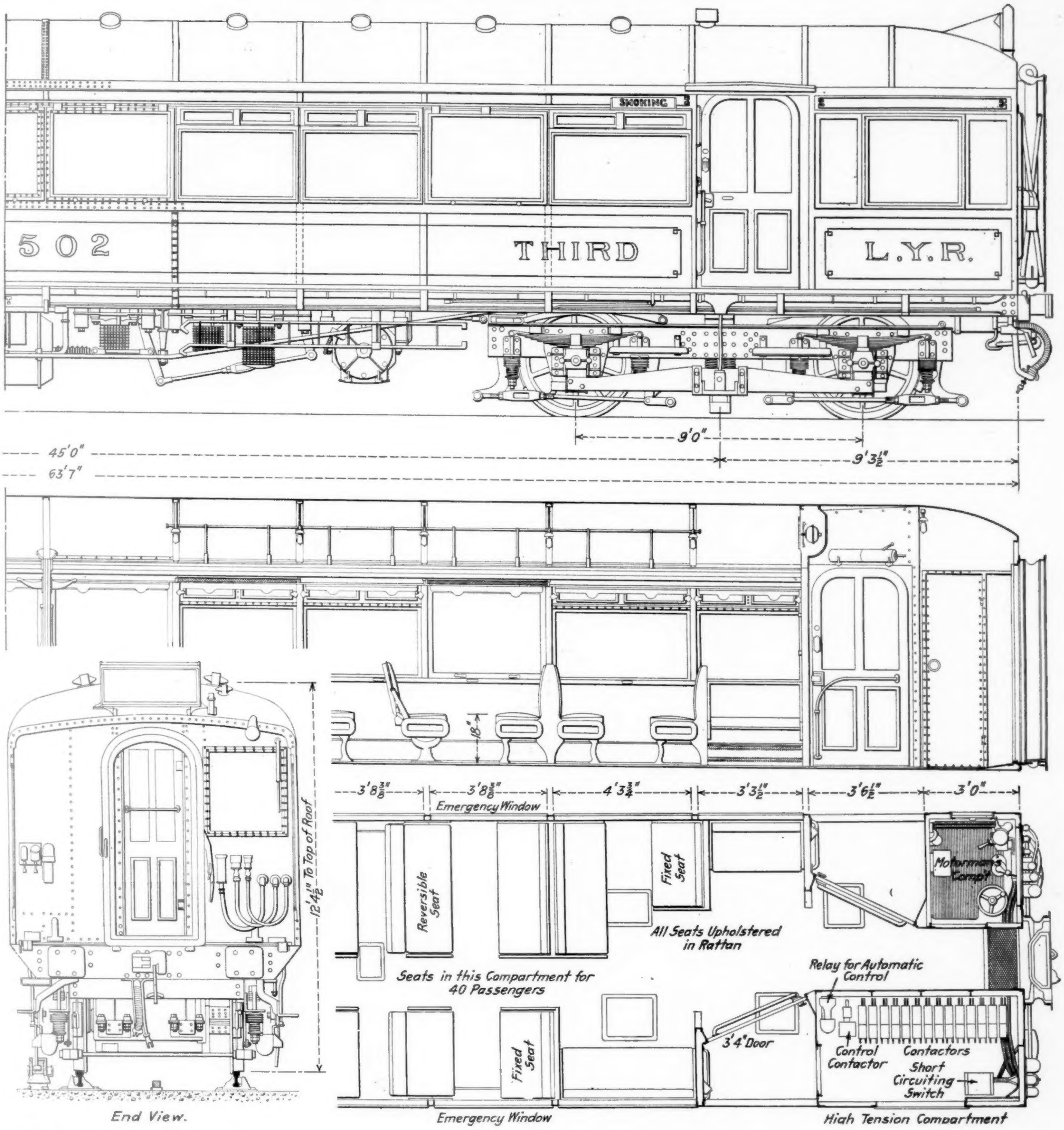
with the top of the side sills and support the "Chanarch" flooring. The side sills are reinforced by $1\frac{1}{2}$-in. truss rods which bear on 5-in. by 8-in. I-beams, located 5 ft. either side of the center of the car. The end sills are 10-in. by $3\frac{1}{2}$-in. channels. The body bolsters are built up of four $3\frac{1}{2}$-in. by 8-in. angles, with $\frac{1}{2}$-in. side plates and cover plates. They are attached to the side sills by steel pressings, and are further reinforced by pressed steel gusset plates. The draft gear is anchored in a 9-in. by 4-in. I-beam extending across the car between the side sills and located about 2 ft. 6 in. back of the end sills. This end construction is further strengthened by four intermediate angles ex-



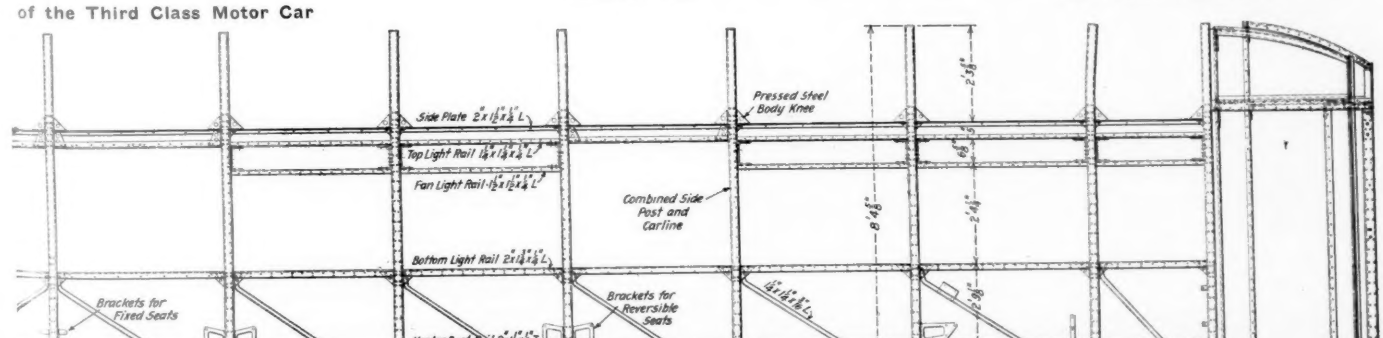
Side Elevation and Sections



Side Framing for



of the Third Class Motor Car

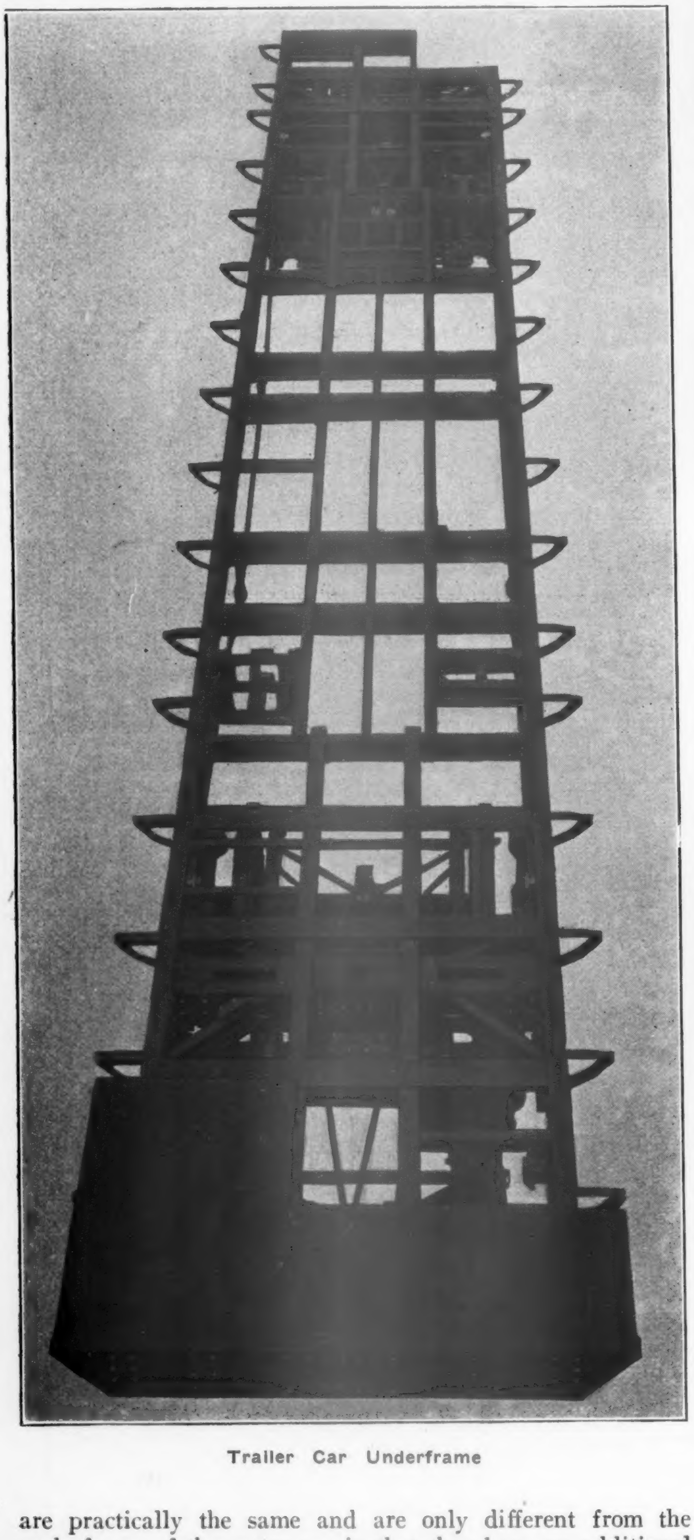


Third Class Trailer Car

tending between the end sill and the I-beam, two of which are 3-in. by 3-in. and the other two 3-in. by 8-in. by 3/8-in. alloy steel angles. All of these angles have a side plate of 1/2-in. material.

The intermediate sills and crossbearers on the motor car are cut short just over the trucks in order to provide proper space for the motors.

The underframe for the first and third-class trailer cars

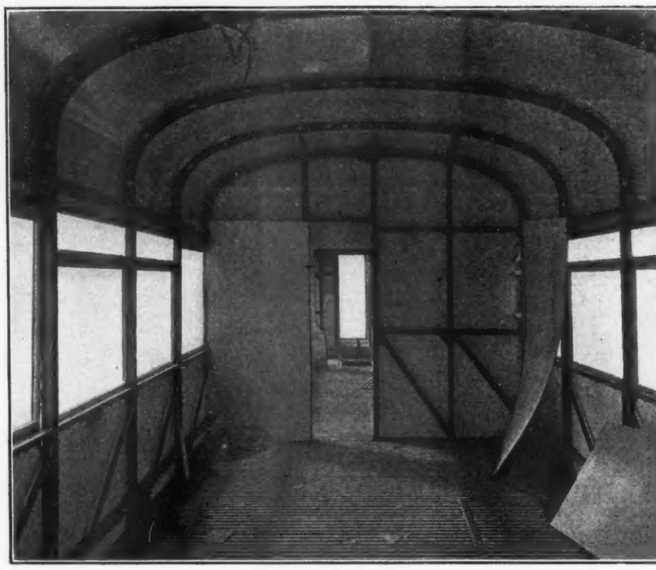


Trailer Car Underframe

are practically the same and are only different from the underframe of the motor car in that they have an additional intermediate sill made up of a 2-in. by 3-in. by 1/4-in. angles. They are also further strengthened over the trucks by cover plate strips and by two intermediate sills made up of 4-in. by 2 1/2-in. by 5/16-in. angles.

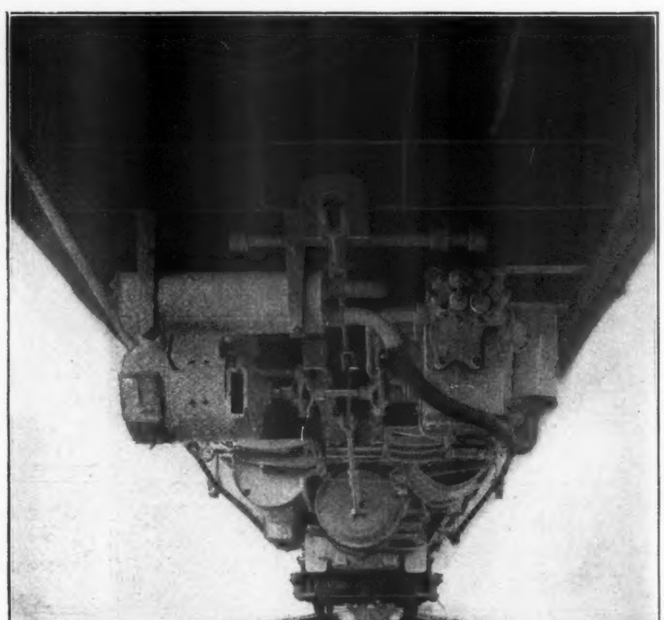
Superstructure

The superstructure is designed to carry part of the load and acts as a continuous side girder to the underframe. It is made up of a bottom side 2-in. by 3-in. by 3/8-in. angle, which is riveted to pressed steel brackets extending out from



Interior View of Motor Car During Construction

the side sill of the underframe to which they are riveted. The side posts and carlines extend in one piece from the side sill to the ridge pole. They are 2 1/2-in. by 1 3/4-in. alloy-steel channels being bent and riveted to the side sill brackets at the bottom and united at the top by a plate riveted to the webs of the channel. They are equally spaced throughout the center of the car on 3-ft. 10 7/8-in. centers. At the ends the spacing is a little closer together. They are braced by a belt rail of 2-in. by 1 3/4-in. by 1/4-in. angles, located approximately 2 ft. 8 in. above the lower angle; by an upper



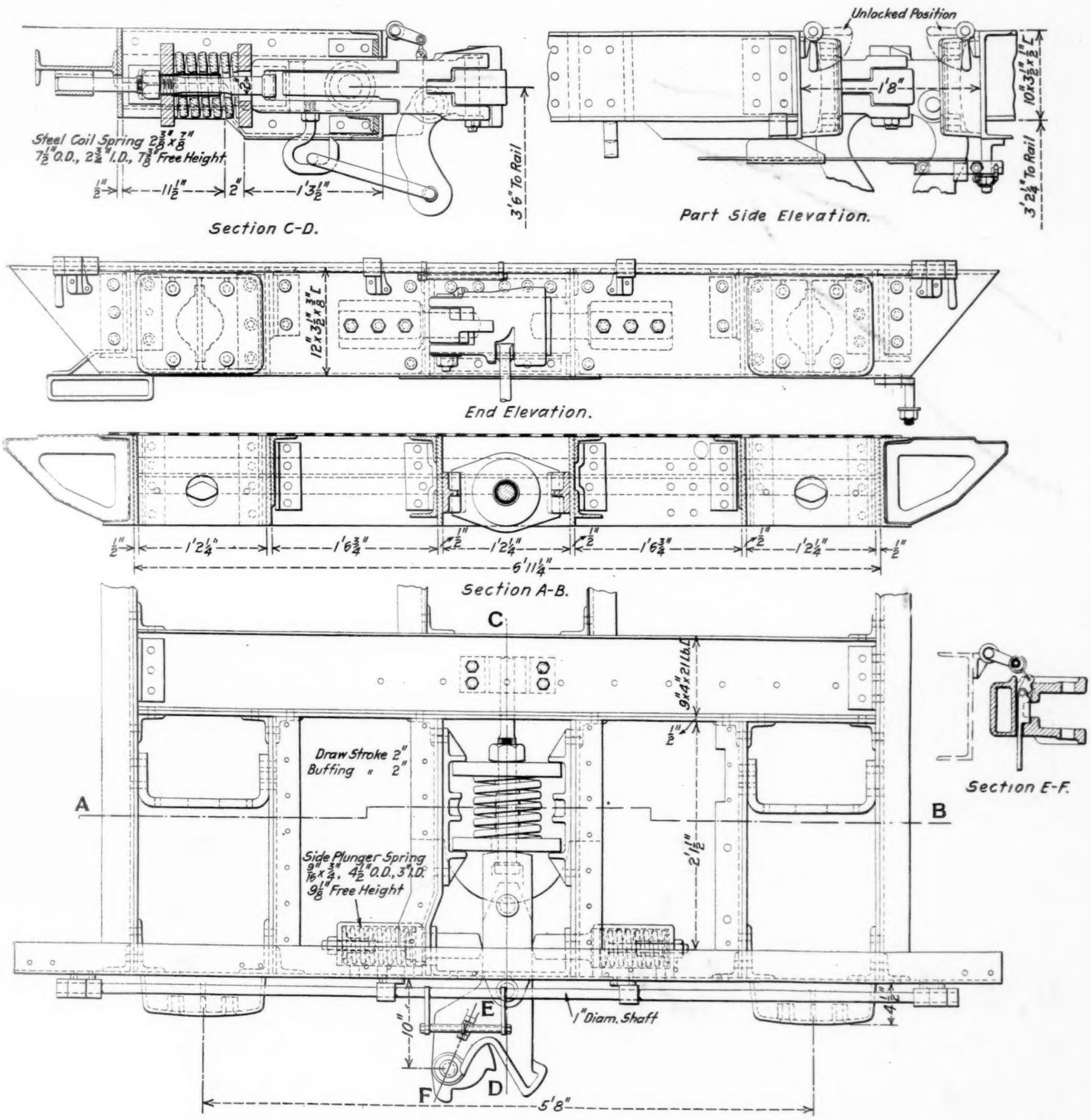
Equipment Beneath the Car Underframe

belt rail of 1 1/4-in. by 1 1/4-in. by 1/4-in. angle, and a side plate or cant rail of 2-in. by 1 1/2-in. by 1/4-in. angle. In addition to this there are diagonal braces of 1 1/4-in. by 1 1/4-in. by 3/16-in. angles extending from the juncture of

the lower belt rail with the side posts to the 2-in. by 3-.in. by 3/8-in. angle bottom side rails.

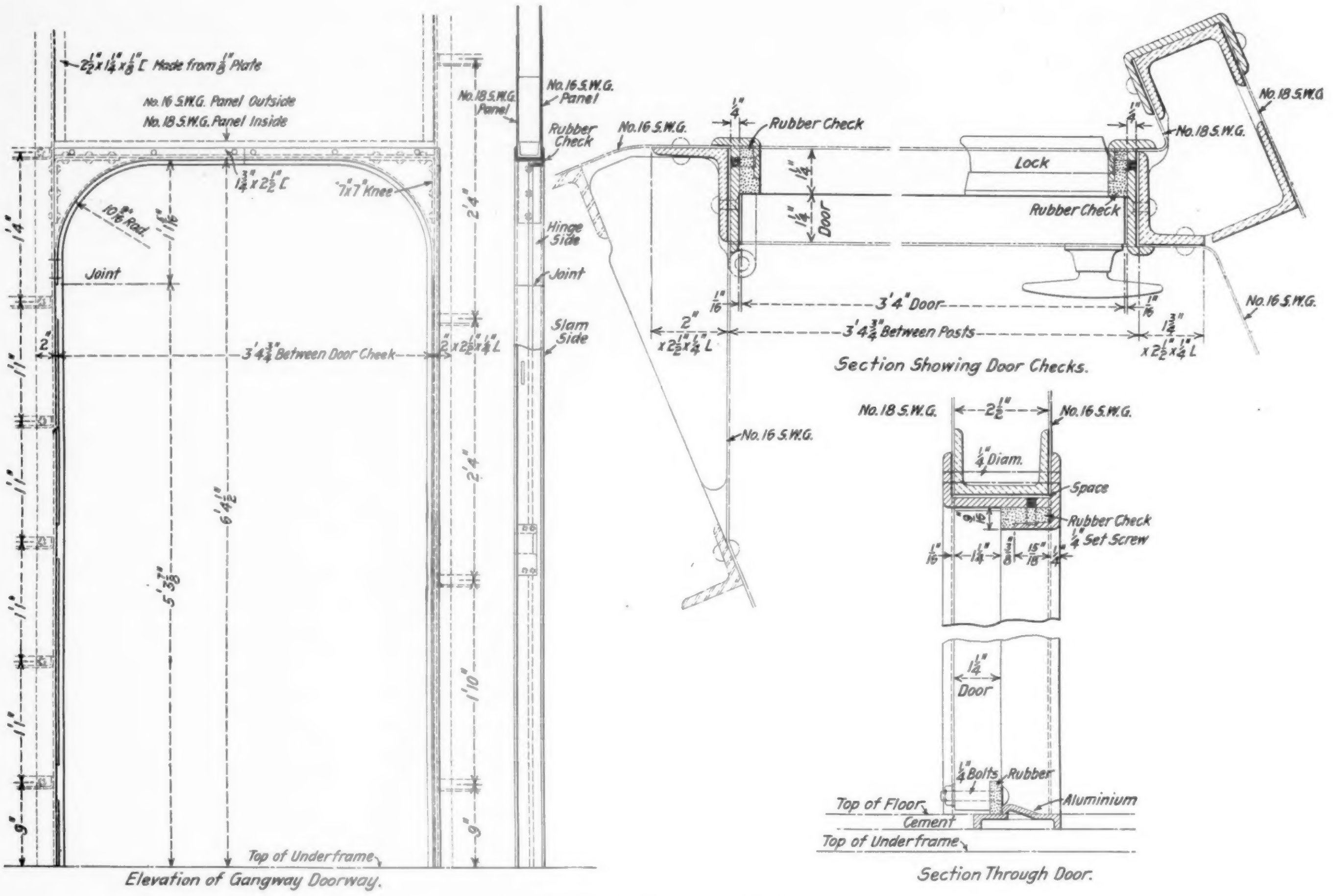
All the longitudinal rails are connected to the side posts by pressed steel knee plates. In addition to these longitudinal rails there extends along the lower part of the body structure a heater duct rail of 2-in. by 1 1/2-in. by 1/4 in. tee. There are other longitudinal rails extending between the side posts, which give the structure additional strength. The side and roof plates are of aluminum. The roof sheets are made up of aluminum plates 12 ft. by 4 ft. 6 1/4 in. by No. 14 S. W. G. They are carried in one piece from side to side and are joined to the carlines with 2-in. by 1-in. strips of aluminum, which are well lagged and which are double riveted with 1/4-in. aluminum rivets spaced at a 3-in. pitch. In as much as the climate in which these cars are to be run is neither excessively cold nor excessively hot, it was unnecessary to insulate the roof, and as the appearances do not require it no inner roof was used.

The sides of the cars below the windows are sheathed with No. 14 S. W. G. outside aluminum plates and No. 18 S. W. G. inside aluminum plates, with an air space of 1 3/4 in. between them. The inner sheathing was to improve the appearance of the car and also to serve as insulation. The side window frames are of aluminum and are riveted to the side posts and rails with 1/4-in. aluminum rivets. The glass is embedded in felt and secured by a wrought iron frame secured to the main window frame.

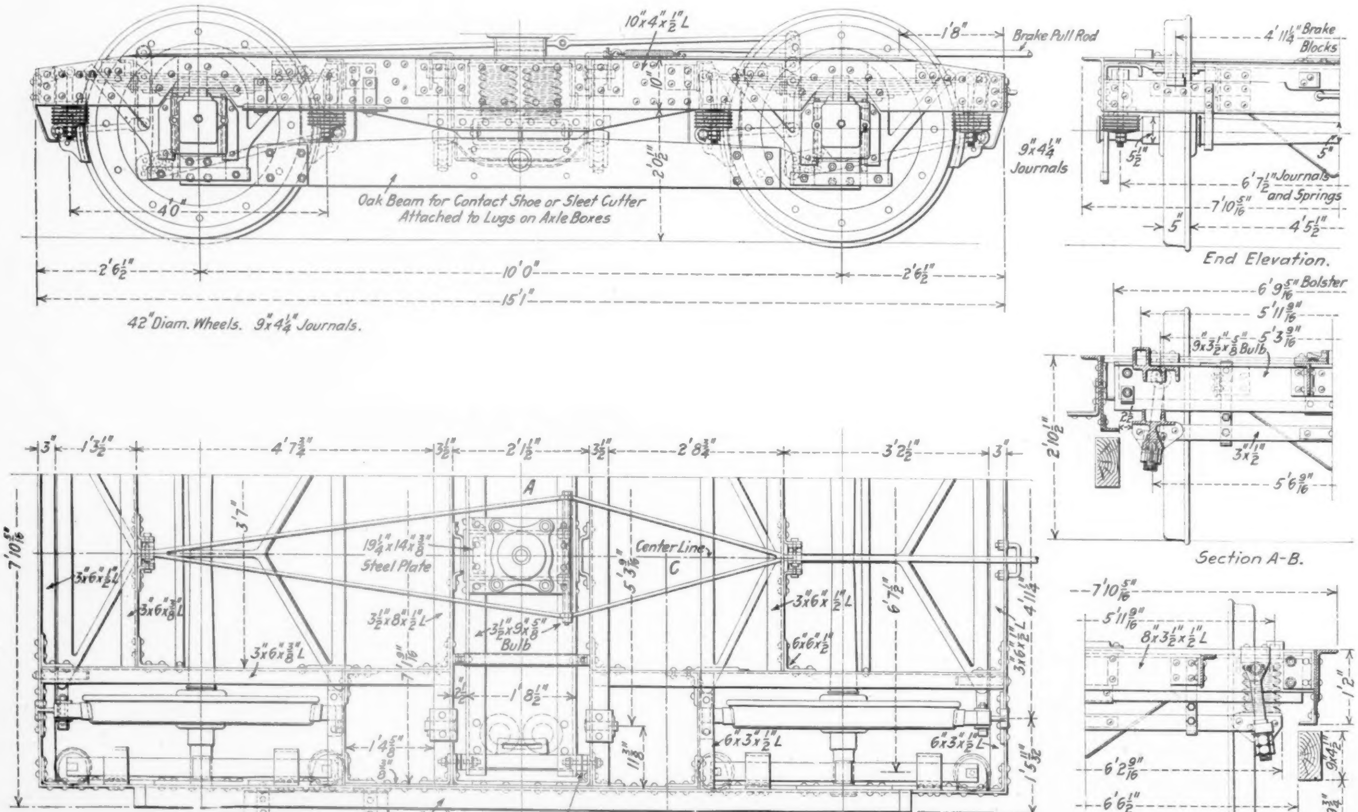


Arrangement of Automatic Coupler and Draft Gear

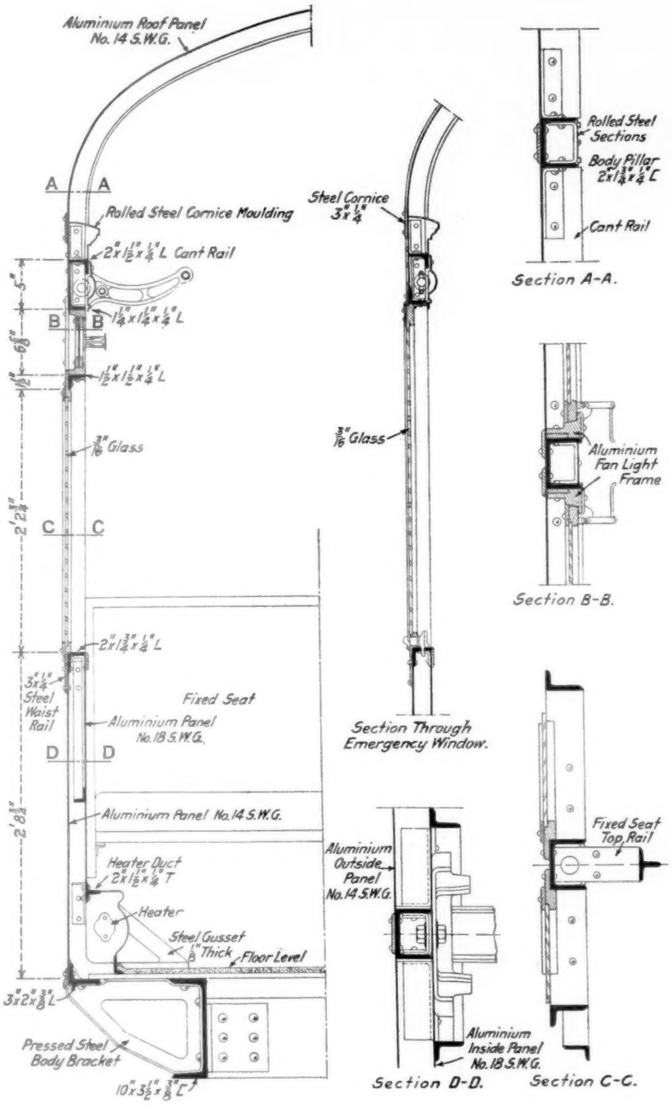
As will be seen from the drawings showing the seating arrangements, some of the seats of the third-class cars are placed back to back. The outside ends of both the fixed and the reversible seats are supported on brackets riveted to the side posts.



Arrangement of Gangway Doorway



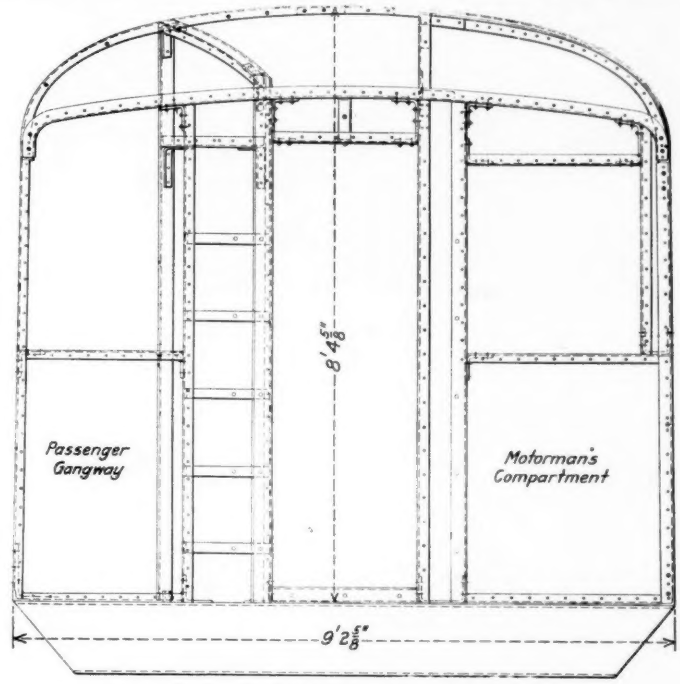
Truck Used on the Trailer Cars



Section Through Body Structure

Doors

The arrangement of the doors is rather unique. In keeping with the all-metal construction of the car, these doors are of steel, having been furnished by Heywood Bros. & Wakefield Co. (United States). They are hinged on the inner door posts and arranged to swing outward, which greatly expedites the unloading of the cars. They are fitted

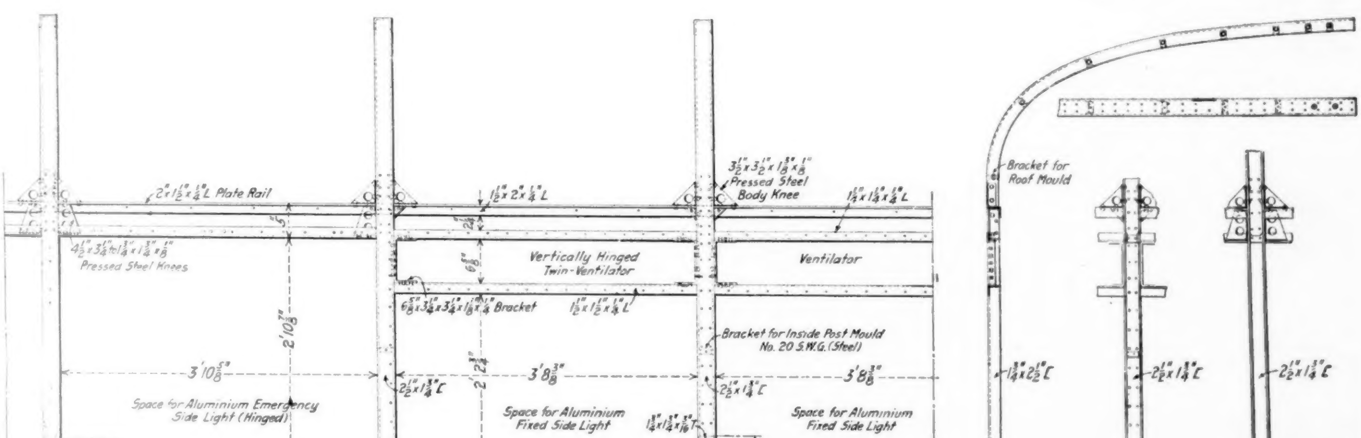


End Elevation of the Third Class Trailer Car

with an india-rubber welt in the door check to provide a water-tight joint and to eliminate any metallic sound when the door is closed. They weigh 141 lb. each, as compared to 114 lb. for oak doors.

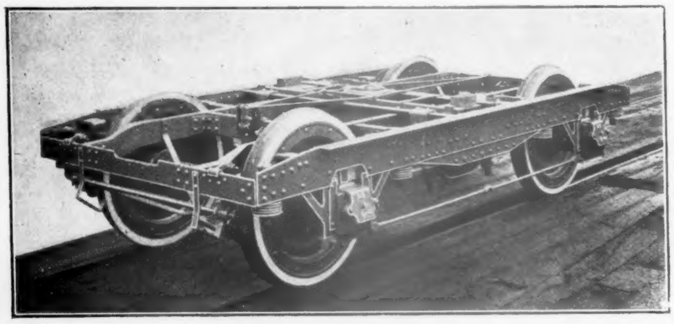
Trucks

The trucks for the motor and trailer cars are of similar construction, those for the motor cars being built of heavier



Details of the Body Framing for the Motor Car

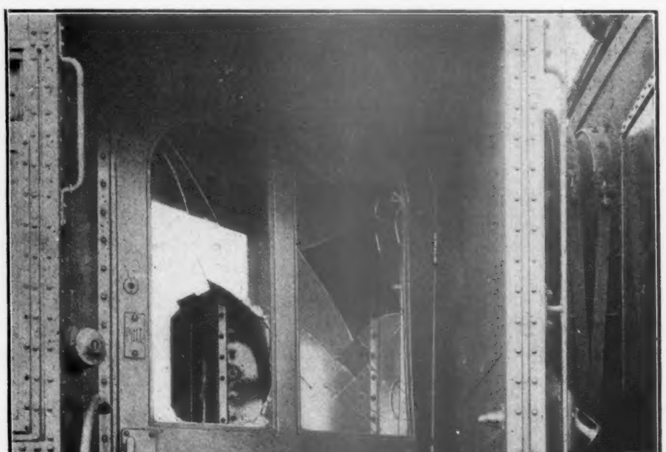
materials. Both are built up of structural steel, with box girder bolsters having a lateral swing of 1½ in. in each direction. Four helical bolster springs are used, and semi-elliptical springs are used over each pedestal. The body framing of the motor truck is made up of 12-in. by 4-in. by ½-in. angles, being provided with heavy gusset plates



Trailer Car Truck

at the top. The truck bolsters are made up of 8-in. by 3-in. by 1½-in. angles.

The trucks for the trailer cars have a body frame made up of 4-in. by 10-in. by ½-in. side angles and 3-in. by 6-in. by ½-in. end angles. The truck bolsters are built up of 9-in. by 3½-in. by ⅝-in. bulb angles, with 8-in. by



Rear End of Car, Showing Damage to Door in Collision

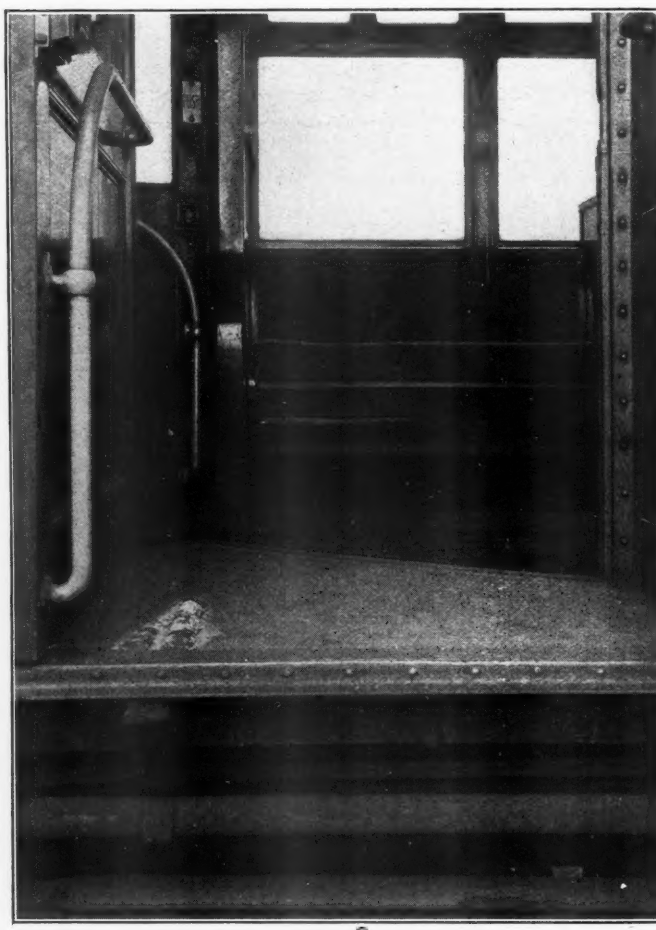
3½-in. by ½-in. angles for the transoms. The side bearers are located 5 ft. 11 9/16 in. between centers.

The motor trucks have a wheel base of 9 ft., which gives ample room for the two 200 hp. motors. The trailer trucks have a wheel base of 10 ft. In both cases the diameter of the wheels is 42 in. and the journals are 9 in. by 4¼ in. for the trailer trucks and 10 in. by 5 in. for the motor trucks. The driving gears for the motor trucks are pressed on to the axle, and in addition are bolted to the truck wheels in order to relieve the axle of severe torsional strains.

A gearing ratio of 2.36 to 1 is provided. The clasp type of brake is used on both trucks. The brake shoe is solid and of sufficient hardness to give a mileage of 8,000 miles.

Maintenance

In a paper before the Institute of Civil Engineers a short time ago both George Hughes, chief mechanical engineer, and F. E. Gobey, assistant carriage and wagon superintendent of the Lancashire & Yorkshire, discussed the question of maintenance of these cars. There have been in service for three years 46 of these all-metal cars. They have averaged 250,000 miles per annum and have operated in temperatures varying between 20 deg. F. and 120 deg. F. There has been no weakening since they were first placed into service



Showing Damage to Gangway in Collision

in any respect. The flooring composition has had no effect whatever on the floor sheets, but the original ⅜-in. thickness upon the top of the sheets is slightly worn in the aisles. It was found that aluminum oxidizes in contact with "Flexolith," and in this case aluminum has been replaced with brass.

The removal of the inside panels does not show that any corrosion or sweating has taken place on either body, framing or the inside of the outer panels. The actual car repairs in traffic have been slightly less than for wooden cars during a similar period. The all-metal cars are overhauled every two years, and it is expected that less material and labor will be required on them than for wooden cars.

The motors are given a general overhauling every six months, when the car body is removed from the motor trucks,

the motors taken out, the armature removed, the commutators examined, turned up and the mica undercut if necessary, the brush-gear overhauled, the armature windings cleaned, blown out and varnished, the field frame cleaned and connections examined, the motor trucks inspected, the wheels turned up if required and the bearings adjusted. Every 12 months the electrical equipment is overhauled. The average total number of faults per month for the 12 months ending July 31, 1918, was 72.4 and the faults per thousand motor-car miles was 0.78, of which the control equipment was responsible for 0.4 and the motor, motor trucks, cars and subsidiary equipment was responsible for 0.38, the largest of which was 0.13 for the subsidiary equipment. The reasons for the defects of the control equipment being so high was on account of the automatic control, which very largely increases the number of small parts.

In comparing the performance of the new all-metal cars with the cars of composite construction used on the Liverpool-Southport line, it is found that the faults per 1,000 motor-car miles was practically the same, being 0.76 on the Liverpool-Southport line as against 0.78 on the Manchester-Bury line. The greatest trouble in the Liverpool-Southport line was given by the motors, which average 0.26 faults per thousand motor-car miles.

The performance of the all-metal cars in collision has been demonstrated by three collisions that have taken place, in which it was found that the damage to the all-metal cars was confined to the ends of the cars. The doorways are the principal buckling points, which, being at the extreme ends of the cars and having vestibules, absorb the blow. The light car structures minimize the force of impact, and the effects of the collision where the metal framing is suitably disposed. There was no difficulty in carrying out the repairs in the car shops. The metal structure absorbs collision shocks in less space than the wooden cars, with the resultant effect that there is less liability of injury to passengers. Some illustrations are included to show the effect of collisions on these all-metal cars.

The Inspection of Freight Equipment

The Defects that must be Avoided in the Selection of Freight Cars for Certain Commodities

BY L. K. SILLCOX
Master Car Builder, Chicago, Milwaukee & St. Paul

In any successful movement of traffic it is of prime necessity to first see that cars going to industries, loading stations or loading territories beyond the reach of local car repair points are gone over and put in suitable condition to run to whatever destination they may be scheduled to reach; also that they are in fit shape to carry the lading which they are intended to carry, this to avoid delay in movement, damage claims or the necessity of transferring the load en route. For this reason large terminal loading tracks should be piped with air and have suitable repair materials and facilities conveniently placed. In the past entirely too little attention has been given equipment at loading platforms at large industries, when it has been a matter of daily experience to have cars brought right over at the close of the day and placed in our most important time freight trains, and then there was not time enough allowed to do the necessary work on the equipment, the latter being true since no effort had been made to put the cars in shape while they stood idle during the day. The result is obvious, and with the matter brought out so clearly and being one of daily observation we must make the necessary effort locally at every station on the system to correct this state of affairs at once. No one could possibly estimate the great and tremendously far-reaching effect of this and what good may result when this item is properly understood and uniformly applied.

A box car to handle grain, flour, sugar or groceries should be in the best condition possible. The siding must be tight, the roof non-leaking and the floor and lining level and smooth, so as not to chafe or injure the contents. Wool, raw cotton, hay, brick, etc., may be handled in a car in fair condition without damage. A leaky roof or open siding will not injure these articles, and they cannot fall through cracks in the floor as would bulk grain. The only essential for cars handling the last mentioned articles is that the frame work of the car be strong enough to hold the load and that the trucks and draft gear be in good condition.

A refrigerator car must always be in good condition in order to protect its lading, due to the fact that the requirements of this service are very rigid. A stock car should be in good condition in order to handle live stock without damage, but the same car in fair condition will haul barreled goods, rough lumber, ties, lump coal and many other articles very satisfactorily. A gondola must be in very good condition to hold slack coal without loss, but will hold lump coal, coke, scrap iron, etc., if in only fair condition. Trouble is experienced when we get out into the lignite coal district. If any old car is used for this coal loading, the car and contents are both liable to be burned up. A pretty good car must be used on account of the fire risk.

There are a good many commodities that should never be loaded in a first-class car, and this is one of the worst practices that is prevalent on railroads today—the abuse of good cars by loading certain commodities in them. For instance, hides, fertilizers, immigrant outfits, scrap iron, coal, pitch, oil, refuse from sugar factories, tar and things of that kind should never be put in a first-class car. This matter should receive more attention than it does at present. If we have around 75 per cent, or about three-quarters of the box cars in first-class condition we ought to be able to take care of our business in a satisfactory manner. By first-class condition is meant a car that is good enough to handle grain or similar products.

In order to define the requirements of cars for various commodity loading the following will govern:

Grain Cars

A suitable car for bulk grain loading is one that has the decking, lining, sheathing, posts and grain strips and roof in a good, tight condition, or in other words, *will not leak grain,* or a car which can be made fit by the shipper at the time and place of loading by ordinary and proper care in the use of coopering material and by a reasonable amount of cleaning. A car with doorposts shattered or broken or loose from the framing, or with other defects of such character as to render the car obviously unfit, or with the inside showing the presence of oil, creosote, fertilizer, manure or other damaging substance of like or kindred character should not be used for grain. Where a shortage of suitable cars ob-

Continued from the January issue.

tains, it is often desirable and necessary to fit cars up especially, and under these circumstances, where the body of the equipment can be made fit and suitable in 20 carman-hours or less, it should be done. This work is usually carried out under extreme pressure and may consist of employing anchor bolts to secure door posts, slabbing the sheathing at both the end and sides to sills, reinforcing broken posts with old iron, such as levers, threshold plates, iron scraps and applying a supplementary end lining over the old or defective structure, including false bulkheads in the body of cars, jacking bulged out ends in place and applying straps, anchor rods or bars, slabbing side or end plates, slabbing belt rails, patching sheathing, roofing and floors with old metal roofing. Under all circumstances the running gear, brakes, wheels, lubrication and safety appliances must be in as nearly 100 per cent condition as possible. All of the above is exclusive of applying grain doors, as these are installed by the shipper. In delivering empty cars suitable for grain loading to our connections, it shall be the understanding that the cars which cannot be made fit with the expenditure of ten carman-hours shall be returned, the same to be true as a basis of acceptance between connecting lines giving us care for such loading and ourselves. In further explanation, box cars which are fit, or such as have light running defects, will be accepted or offered on an equal basis. In order that there may be a universal understanding as to what is meant by the term "light running repairs," it will be understood that this covers cars having such defects as missing plain wooden side doors (this not to include Wagner or other special all-metal or steel-bound side doors), broken draft timber or strap bolts, slight defects to wooden or metal roofs, to side or end sheathing and lining, or other light running repairs such as can be made by the receiving line on division or yard repair tracks within the time allowance prescribed, or such as can be coopered by the loader to make the body fit for the lading intended.

Flour Cars

In going over cars for flour loading, the main points to be considered are a good, tight roof and sides, good, close-fitting doors, a good, clean floor and freedom from the presence of oil, creosote, fertilizers, manure or acid spots which are liable to contaminate the lading. Roofs to be given water test where possible. A car that has been loaded with hides should not be used for flour, or any other car that has been loaded with commodities which have left a bad odor. During the winter months cars equipped with all-metal roofs or ends uninsulated should not be selected for flour loading unless it is distinctly understood that the doors will be left open at least four hours after being loaded, as when hot flour is put into a cold car that has an all-metal roof or end exposed in the interior it causes the metal to sweat, and the moisture dropping down on the sacks injures the flour.

REPAIRING FOREIGN CARS

In handling repairs to foreign cars which are in need of heavy work, either on account of deterioration, damage or wreck, the following should be remembered:

It is necessary that division terminal stations which are equipped with planing mills, compressed air facilities and steel working tools, give attention to the classified repairs on foreign cars which are of such construction, so that when repaired and put in first-class shape they will be available to our service. Under these circumstances cars with steel underframe, steel center sill or steel draft arms (arms to extend at least 30-in. behind bolster) should be selected in the order named and box cars should be given preference over other types.

We should aim to do the best possible work on foreign cars coming to our repair tracks and turn them out in fit condition to properly meet traffic and commodity requirements. For instance, when a foreign car comes in for attention to the draft sills or steel underframe, if in such condition as to require also new sheathing, roof, floor or lining, end or posts, doors, bolster, or draft gear, etc., and suitable material is in stock the car should be put in first-class shape. The main shops at Milwaukee, Dubuque, Minneapolis, Green Bay and Tacoma are doing this now. This plan must be strictly observed in order that we may be in a position to bill against foreign lines to an equal or greater amount than they are billing us for repairs to our cars on their lines.

It was mentioned in the paragraph just preceding that steel underframe equipment or cars of like construction should be selected, the reasons being obvious. On the other hand, cars more than fifteen years old, which are of weak construction, generally equipped with short wooden draft timbers, and which appear to be in an unsafe condition to run and if rebuilt would probably not stand up under present service conditions, are to be set aside, written up on form CD-27 for disposition and this office will in turn take the matter up with the car owners to secure authority to strengthen and rebuild, dismantle or send home empty. Every effort must be made to keep such cars off the railroad and where found empty in this condition they should be held so as not to cause damage and difficulty to other good cars in service, also where coming to repair tracks under load they should be transferred and reported as above, unless we have a near connection with the car owner.

Precautions should be taken not to spend more than $250 on any foreign car of 40 tons capacity or over and which is less than 12 years old. Roughly speaking, this expense will permit the application of an entire new roof, two side doors and light repairs to the draft gear, couplers, boxes, wheels, etc. It is not intended to apply a whole new superstructure or underframe, without obtaining the appraised value of the car from the owner and determining whether we can settle for less expense than the authorized repairs.

Cars of 30 tons capacity and equipment more than 12 years and not over 18 years old should be limited to $100, which will allow for the application of an entire roof, or two ends, or flooring and doors, or new sheathing, or two longitudinal sills, draft sills and end sill, but as already stated only such cars which are equipped with steel underframe, steel center sills or steel draft arms extending back of body bolsters should be extensively repaired. Cars not coming under the above classes should be held for disposition.

Cars must be written up promptly on form CD-27 and when the report is received in this office we will send a copy of form CD-27 to the owner. If a reply is not obtained from the car owner within 30 days, we will take the matter up with our executive officer who will get in touch with the car owner's executive for immediate response; the same is true of material required from owners to make repairs to their cars. It is not intended to hold cars more than 30 days and the foreman should keep after the master car builder continually if instructions for disposition are not received promptly. Billing must be kept up to date and properly checked at all times.

General Conditions Governing the Repainting of Foreign and System Freight Cars

The preservation of freight car equipment of all railroads will be maintained by the necessary repairing and restenciling. When paint on freight equipment has perished to the extent of permitting the steel to rust and deteriorate or the wood to become exposed to the weather, the car should be repainted. The body (including the roof) should be entirely repainted if for any reason it is found necessary to re-

paint one-third or more of the car. Before applying paint to steel or wood it should be scraped so as to clean off all blisters and loose paint, also removing protruding nails and tacks.

When repainting freight equipment cars, two coats will be applied to all new parts and old parts of the body which have been reworked causing removal of the paint. One coat will be applied to parts where the old paint is in good condition. Should the old paint be found in such condition as to require two coats, they may be applied.

The station marking showing where the car was last weighed should not be changed unless the car is reweighed. The stenciled letters and numbers on all freight equipment cars will be maintained and the identity kept bright. When the lettering or numbering is found in bad condition, the identifying marks should be renewed either by repainting the car or by applying new stenciled letters and numbers. In selecting cars for this purpose, preference should be given those on which the marking and painting is in the poorest condition. Do not cut stencils for special marking such as the monogram on Great Northern, Santa Fe or Southern Pacific cars.

If there is not sufficient paint on the car properly to retain the new stenciling and the condition of the car does not justify entire repainting, one coat should be applied as a panel back of the stenciling so that the paint used in applying the numbers and letters will hold, otherwise the marking applied will soon become illegible, making it necessary to again apply the identity marking within a short period. Detention of equipment from service for painting should be avoided, when possible. A great deal of this work can be done to open cars in transportation yards when under load in storage.

These instructions apply equally to foreign and system cars and all should be repainted in accordance with the above instructions when on repair tracks, regardless of ownership. Charges for repainting and restenciling are to be made in accordance with the A. R. A. rules.

Date and Year Built

The A. R. A. rules provide that after September 1, 1919, cars will not be accepted in interchange unless stenciled showing the month and year built, or bearing a badge plate giving this information. Cars built prior to 1895 may be stenciled "Built prior to 1895" or bear a badge giving this information. In the case of tank cars, the body and tank should bear distinctive dates unless constructed at the same time.

Repairing Cars at Loading Tracks

At many terminals there is a loading or transfer track where cars are lined up and are not switched for almost 24 hours. At places where these conditions exist every effort must be made to have the proper number of men assigned to inspect and to repair all possible defects on these cars. There is much work that could be done even to the extent of caring for the air brakes. Brakes that are out of date could be cleaned and after they are cleaned the aid of a switch engine could probably be gotten to assist in testing the work at its completion. At this time the piston travel could be checked and the hose tested for porosity. All work done on cars at these loading points relieves the outside yard of just so much work, and inasmuch as it is much safer working on a car where there is no switching, as stated before, the efforts of all should be concentrated on this feature.

Repair Parts and Tools

Inspectors must keep constantly on hand for repairs a supply of all parts of the equipment that are liable to get out of order and which can be replaced while the car is in the yard. However, unless the proper tools and appliances are at hand, nothing will be accomplished, therefore, inspectors should see that they are furnished with the necessary tools. Air brake inspectors should have with them at all times a pipe wrench, for use on the train line and retainer pipe, an S-wrench of the proper size to tighten up the pipe clamps, a coupling groove cleaning tool, which should always be used when renewing gaskets, a cotter key and lever pin drift, and a supply of cotter keys and nuts of different sizes. There should be no excuse for failing to have the necessary repair parts and tools with which to apply them with, because inspectors and repair men would be of little use if they were not able to repair defects which they find.

Old Date Air

All cars marked for bad order triple valves or brake cylinders, as where the brakes either will not apply or leak off quickly, should be treated the same as cars with the brakes out of date (system cars 9 months, foreign cars 12 months). On repair tracks all cars with the aforementioned defects must be repaired but in yards a certain amount of discretion will have to be used. Cars loaded with manifest freight which cannot be held a sufficient length of time to make the necessary repairs, will have to be allowed to proceed, but the car must be properly carded and when its destination is a terminal, must be marked bad order when empty, stating the reason. Empty cars which are to be assigned to shippers to be loaded on our lines must positively have the brakes cared for before being allowed to proceed.

Damage and Loss

Damage or loss to any car, due to wreck, derailment, cornering, sideswiping, flood, overloading, explosion, collapsing structures, or unconcealed fire damage, including cars on ferries or floats; also damage due to storms where the car is derailed or destroyed is chargeable to the railroad holding the car in its possession at the time. Defect cards are not required for any damage so slight that no repairs are necesary, nor for raked or cornered sheathing, roofing, facia, or bent or cornered end sill, not requiring the shopping of the car, the receiving line to be the judge. In case of interior fire damage, in any class of car, if evidence of such internal damage was not discernible externally, it is considered an owner's defect. When flooring planks are out and can be seen from the outside of the car, they are cardable defects. When paint is missing in spots, due to hot lading, such as pig iron, billets, cinders and blooms being loaded in cars, is not a cardable defect unless the damage is such as to require the shopping of the car.

Temporary Transverse Tie Rods Applied to Cars with Sides Spread or Bulged

Owners are responsible for the expense of applying tie rods, when these are necessary to allow the equipment to pass the clearance limits of the handling line.

DEFECTS OF VARIOUS PARTS OF CARS

Sills

Sills of both wood, steel, and steel underframe cars and cars with metal draft arms, should be carefully inspected to see that they are not destroyed, cracked or split on account of draft bolts working in sills or being buckled or broken. Broken, cracked and buckled sills are generally found directly in front of or at the back of the body bolster.

Method of Splicing Sills of Wooden System Freight Cars

Wooden Cars: Longitudinal sills may be spliced at both ends, except that not more than two adjacent sills may be spliced at the same end of the car. The splicing of any sills between cross tie timbers will not be allowed. The splice may be located either side of the body bolster, but the nearest point of any splice must not be within 12 in. of the

bolster, excepting center sills, which must be spliced between the body bolster and cross tie timber, but not within 24 in. of the body bolster.

The splicing of longitudinal sills other than center sills is to be done in accordance with Fig. 1; old splices now on cars may be repaired. Center sills must be spliced in accordance with Fig. 2, when new splices are used. This blueprint provides for a uniform splice for the various classes of cars and must be followed as far as practicable to obtain uniformity and interchangeability of splices. Old splices now on cars may be repaired.

Foreign and Private Line Cars: Longitudinal sills when broken may be spliced in accordance with the A. R. A. rules

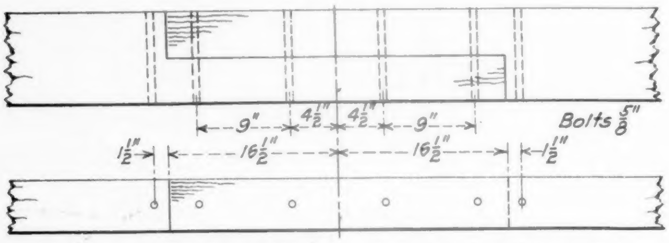


Fig. 1. Splice for Longitudinal Sills other than Center Sills

of interchange and the details of the splice must conform thereto.

Note: In splicing the sills of foreign and private line refrigerator cars, care must be exercised to see that the insulation is replaced in accordance with the original construction to avoid being penalized for wrong repairs. in the case of foreign equipment.

Center Plates

Body and truck center plates should be carefully inspected to see that they are not broken and properly secured in place, the bolts and nuts tight and the center pin in position properly secured to prevent loss when cars are turned over on dumping machines.

Truss Rods, Struts, Saddles, Washers and Nuts

On empty cars passing over repair tracks, through transportation yards or in storage, every opportunity should be taken to see that truss rods are properly tightened, so that the cars will have at least 1½-in. camber in the center. Turnbuckles should be properly secured from turning, truss rod saddles, struts and needle beams should be thoroughly held in place and should function properly at all times. Truss rods are to be tightened firmly in place and turnbuckles locked where possible; also saddles are to be properly located and the truss rod nuts on the end sill are to have full bearing and full thread hold.

Draft timbers. Draft timbers must *not* be spliced.

Draft Timber Bolts

Draft timber bolts 1⅛ in. in diameter must be applied to all system cars having draft timbers, center sills or draft rigging applied, these to replace ⅞-in. diameter bolts removed from empty cars on all repair tracks.

Arrangement of Draft Timbers and Wooden Center Sills

Draft timbers and sub-sills on empty cars on all repair tracks must be tightened up and other work done in accordance with standard car maintenance regulations, lock nuts to be applied to all bolts.

When applying new center sills, one keyway only must be cut in the sill, omitting the keyway nearest to the end sill. When applying new draft timbers, one keyway only must be cut in the timber; the keyway in the center sill corresponding to the keyway omitted in the draft timber should be filled with a piece of wood nailed in place. Draft timbers are to be framed and bear against the inside face of the end sill. The use of fillers between the bottom of the center sill and the top of the draft timber will not be allowed.

Cars with Low Center Line of Draft Gear

Every precaution must be taken in connection with cars having a low center line of draft, especially those cars not equipped with draft sills, in order to avoid the wheels interfering with the sills on curves, resulting in broken flanges. It often happens that cars which are difficult to inspect, on account of being low hung, do not receive the careful inspection of side bearings necessary, so that equipment proceeds with side bearings engaging each other, causing derailments.

Continuous Draft Gear

Cars are not acceptable in interchange when equipped with stem or spindle coupler attachments or American continuous draft rods.

Draft Gear

Inspection should be made to see that the draft gear and all its parts are in good condition, carrier irons and straps tight and in place. The coupler should be gaged to see that it is not worn beyond the limit permitted by the A. R. A. gage, also to see that it does not contain cracks that would result in failure. The coupler should be at the proper height as required by the federal Safety Appliance Law. Yoke rivets should be in place and tight. When new rivets are being applied at shops where the facilities are available, they should be 1¼ in. diameter in accordance with the A. R. A. requirements.

The coupler operating mechanism should be in operative condition so as to properly operate the coupler, to avoid safety appliance defects.

It is considered good practice to lubricate couplers as they pass over repair tracks by applying rail grease or the thick sediment taken from the bottoms of oil tanks, which may be applied with a paddle or a piece of waste fastened to a stick. This lubrication is applied to the wearing face of the guard arm of the coupler, and to the knuckle only where the knuckle throwing device bears, to assist in the free operation of the coupler. Care should be taken to keep lubricant off the knuckle lock and the bearing surface of both knuckle and lock.

(*To be continued.*)

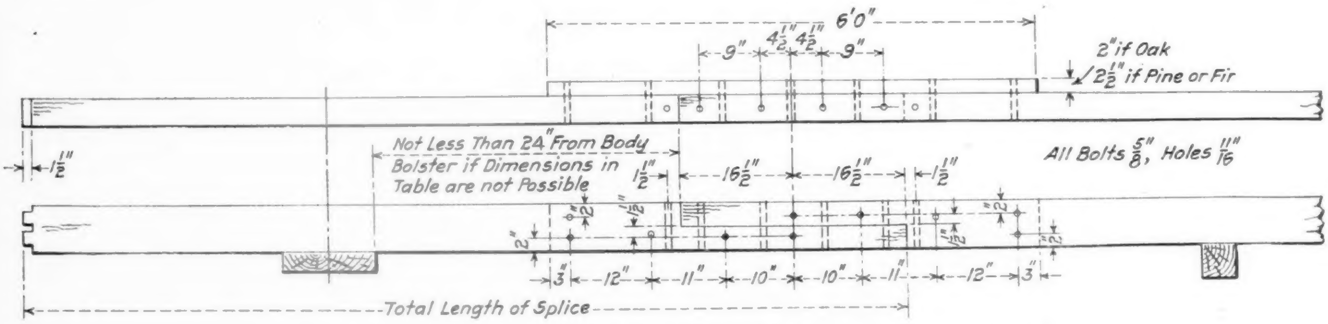


Fig. 2. Splicing of Center Sills in Conformity with the Rules of Interchange

SCHEDULING AND ROUTING WORK IN THE A. E. F. SHOP

Methods Used to Increase Production in the Shop of the Railroad Engineers at Nevers, France

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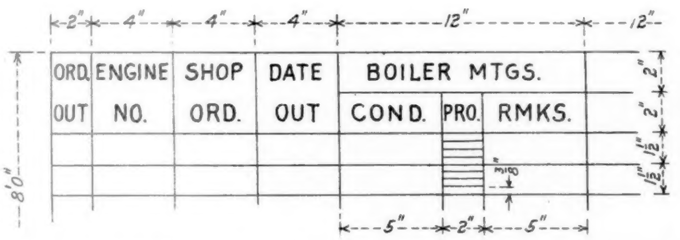
THE writer has long been an advocate of systematic routing of parts in locomotive repair shops and is at the present time more than convinced that routing and scheduling of parts is a practical necessity in a shop on a day-work basis that is of such a size that the machine shop foreman particularly and all other department foremen in general do not know from actual contact the exact status of individual pieces of work.

In shops where no routing system is in effect some pieces of work invariably get buried or lost from sight until the part is actually needed, with the result that the foreman must pay penalty overtime to get the work ready or delay the locomotive for which it is needed. In any case, no system means lack of system and co-operation, with inevitable delay due to haphazard methods.

The routing and scheduling system and the machine-shop percentage board, presented herewith, were inaugurated under



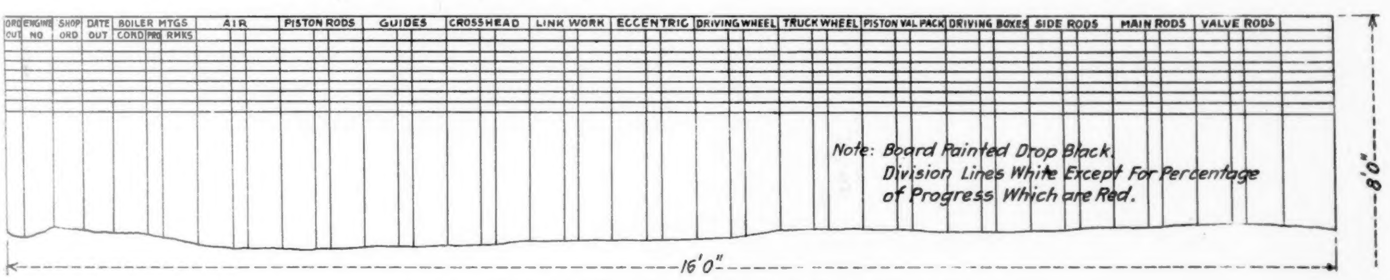


Fig. 1. Percentage Board for Recording Progress of Work

the writer's direction in the Nevers, France, locomotive shop to expedite repairs. Incidentally, no claim is made for originating this method. The system was not new, but rather an application of principles of routing used here in the states in various shops, and was worked out "over there" by men in the shop who had come in contact with such systems in the U. S. A.

The shop was new, the organization was in an embryonic stage, our soldier mechanics were men of unknown ability and experience, our gang leaders were trial selections, the department foremen (commissioned officers) were an unknown quantity, there were no opportunities to go out and select, no time to waste on lengthy educational methods, we had what we had and got nothing else.

The necessity for a smooth-running shop and the maximum output possible was a fact so apparent that there was no disguising the necessity of devising ways and means of crowding the work to the extreme limit. The shop was the only all-American locomotive repair shop in France, completely officered and manned by soldier mechanics of the American army, and as the French shops were run down and depleted of workmen it was the only shop in France where the 1,160 Pershing engines and the 476 Belgian U. S. A. engines could get anything except running repairs. It was also required to handle heavy repairs for the Est., Paris-Orleans, Nord and Paris, Lyons & Mediterranean railways as well as all types and sizes of narrow-gage locomotives (French, Belgian and German), road rollers, tractors, pile drivers, locomotive cranes and the assembly of forestry locomotives.

It is an undisputed fact that method and system are the greatest producers. After about four weeks of operation without what could be called a definite plan of operation, this system was put on trial. Its results were at once apparent and almost immediately justified its adoption in many ways, one in particular being that the general foreman had his finger on the pulse of the organization at all times and, like a general with his war maps and service of information, could plan his strategic moves to the confusion of his old enemy—haphazard methods.

It is a well-understood fact that (a) methods of application and (b) sympathy or the lack of it are the prime movers in establishing any system. This system met with a hearty and enthusiastic reception, which insured its success from its inception.

The method (so called) prior to the adoption of the scheduling and routing system was the custom of establishing a completion date for each locomotive undergoing repairs. This practice is the usual one where the erecting shop foreman looks over the inspection report for the locomotive concerned and "reckons as how" he can get the engine out in an estimated number of days. He has no reliable detailed data on the status of work in the various departments, no particular method of calculation; he bases the date on his experience of the time it should take to complete the repairs, but, like the weather prophets, he occasionally makes a good guess.

There are evidently three factors that must be carefully considered and conscientiously performed to make the scheduling and routing system function properly. First, the joint inspection by boiler and machinery inspectors should be a most thorough and competent one, as it is on this that the "schedule engineer" bases his figures, and a poor inspection will upset all calculations and incidentally the whole shop schedule.

Second, the constants used for individual locomotives and their various parts must be obtained by thorough, careful consideration of all conditions that affect the progress of parts through the shop. A constant sheet worked up for one

shop would be valueless in another unless conditions were very similar.

Third, the schedule engineer or routing clerk, as he is variously called, must be thoroughly familiar with shop conditions and facilities; he must have sufficient mechanical ability to carefully judge the progress of work in order to successfully check the work; he must at all times keep in mind the fact that any newly established sytem ceases to be an innovation after a short time and that as it ages it should become freer running and can be speeded up, and should be in position to shorten up time here and there in order to force production; the summary of these qualifications is that he must be a worker and a schemer.

In connection with the operation of the system a photograph of the locomotive shop chart of February 1, 1919, is shown, with the output of classified repairs for the months of December, 1918, and January, 1919, shown on the right

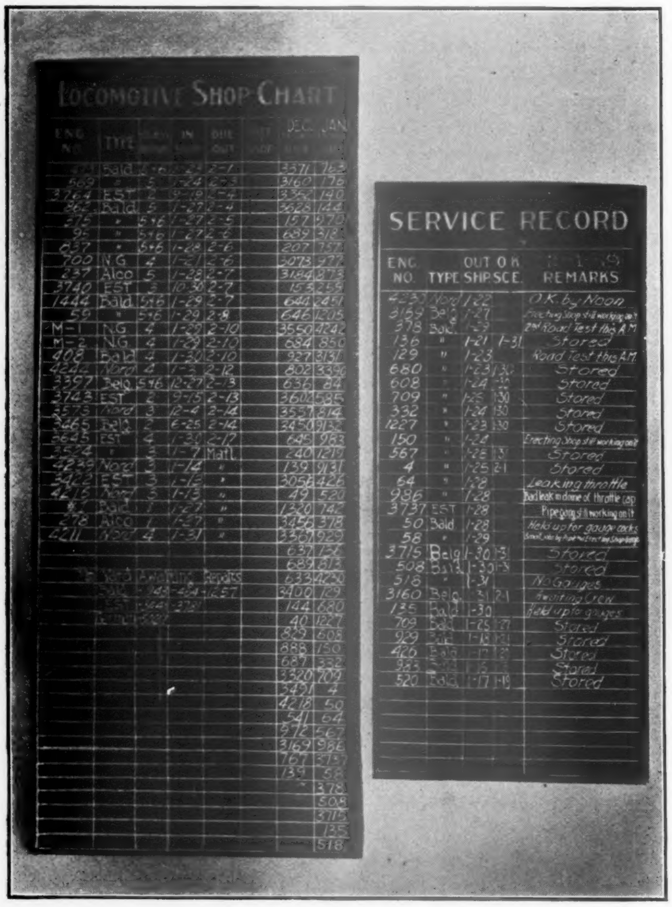


Chart of Classified Repairs, Nevers Shop, Feb. 1, 1919

of the board, a total of 45 and 50, respectively, an increase from 14 in August and 21 in September.

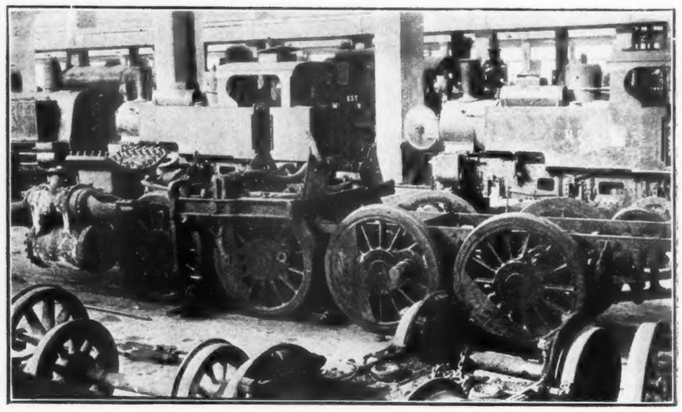
The service record board was used to show all locomotives on hand in the shop yard each day until the locomotive left the premises. It will be noted that but 28 locomotives were booked for February. This is explained by the fact that 500 men were ordered back to the states on February 1, 1919.

Material Checking System

On account of the great number of locomotive parts necessarily handled in the machine shop and the possibility of some of these parts being allowed to remain at any one machine a longer time than necessary, thus delaying the completion of the locomotive in the erecting shop, a material checking system was instituted so as to be in position at all times to tell without difficulty the exact status of all work in this shop. The appurtenances of this system consist of a percentage board, located in the machine shop foreman's office, shown in Fig. 1, and a record kept by each gang leader, Fig. 2.

The sketch of the percentage board explains itself insofar as the general design of the board is concerned. It is only necessary to add an explanation of the method employed in working the board. In the column headed "Order out" are listed all locomotives undergoing repairs in the erecting shop in the order in which they are due out. This is used to determine at a glance whether the work in the machine shop is progressing properly, so as not to delay the assembling of any certain locomotive in the erecting shop. The next two columns are self-explanatory. A column for shop order numbers is necessary at these shops, as a shop order is issued for each locomotive repaired and all labor and material charged to the shop order number instead of to the locomotive number. In the column headed "Date Out" is placed the date the locomotives are due out of the erecting shop.

The remainder of the board, it will be noted, is divided into columns for the various locomotive parts, each having three sub-columns, namely, condition, progress and remarks. In the first column is placed the condition of the part when received in the machine shop. In the column headed "Progress" are shown figures to denote what per cent the work has progressed. When work is started on any part the figure 25 is placed on the first line of this column, indicating



A Scene in the Erecting Shop

that the work has progressed 25 per cent. Parts sent to the machines or parts received back from the babbitting shop or other shops, where they have been forwarded for repairs, are considered as 50 per cent complete, and that figure is placed on the second line. Parts sent from machines to the bench gangs are considered as 75 per cent complete, and that figure is entered on the third line. When the parts are completed 100 per cent is placed on the fourth line. Lesser divisions of progress could easily be used, but it was found that four 25 per cent divisions were small enough for our purpose.

The question that will naturally arise after the above explanation is from what source the information is received as to the progress, so that the entry can be made on the percentage board. This information came from the records kept by the various gang leaders, on the form shown in Fig. 2. Each gang leader had one of these forms on which he entered the progress of the work of his gang and which he turned in at the close of each working day. From this form the clerk in the machine shop foreman's office entered the information on the percentage board.

The column headed "Remarks" was used in cases where locomotives had been scheduled and the parts had not been received in the machine shop, etc. In such cases the word "None" was entered in this column. In cases where parts were received in the machine shop and work on them had not

been started the word "Over" was placed in this column. When parts were sent to other shops to receive repairs and were later to be returned to the machine shop for completion, the shop to which the parts were forwarded was written in this column.

The percentage board enabled the machine shop foreman to readily ascertain the progress of all work in his shop, and if the work was not progressing as it should so as to enable the erecting shop to complete the locomotive by the scheduled date, he could take such steps as would be necessary to bring about the completion of the work in the proper time. This system has proved of great assistance in the supervision of the machine shop.

Locomotive Scheduling and Material Routing System

Frequent delays were experienced, causing necessity for a change in the established date for the completion of locomotives, through the failure of one or more of the shops to finish their work on parts prior to the time they were needed by the erecting shop for application to the locomotives.

In order to overcome this hindrance in the progress of completing locomotives, the "routing" and "scheduling" system was placed in operation during the month of August, 1918. By "routing" is meant the determining of a route or path over which the parts must necessarily pass in the course of repairs. By "scheduling" is meant the establishing of a date when each part is to be received in a certain shop and a date for that shop to complete its work on the parts and pass it on to the next shop. This "routing and scheduling" system was handled entirely by a route clerk and one assistant. It may be well to add that these men were mechanics of known ability to competently judge the status of the work, time required, etc.

Immediately upon receipt of locomotives at the shops for repairs a joint inspection was made by a boiler inspector and a locomotive inspector, who after the completion of their inspection made a joint report to the general foreman showing the principal repairs required. This joint inspection report when received by the general foreman was passed on to the route clerk, who was located in the general foreman's office, with necessary instructions as to the date and location for the engine. From this joint report the route clerk determined the class of repairs that were to be made and the number of days it should take to complete such repairs. The schedule of classification and the number of days allowed for each class of repairs in effect at the shops were as follows:

Ord. out	Engine No.	Shop ord.	Date out	Boiler m'tgs.	Air	Piston rods	Guides	Cross heads	Link work	Eccentrics	Drvg. wheels	Truck wheels	Piston valve pkg.	Drvg. boxes	Side rods	Main rods	Valve rods
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

Fig. 2. Record Kept by Gang Leader

Class	Nature of Work	Number of Days
One	New engine (rebuilt)	Twenty-eight or more.
Two	New firebox and general repairs	Twenty to thirty.
Three	Light repairs to firebox, flues changed and heavy repairs to machinery	Ten to twenty-four.
Four	Tires changed or turned, driving boxes renewed, and other necessary repairs to machinery	Six to eighteen.
Five	Running repairs (heavy)	Two to ten.
Six	Accident repairs	Depending entirely on extent of damage.

For each class of repairs there was a more or less definitely established "Mastersheet." For the type of master sheet used reference is made to Fig. 3, compiled for a Consolidation type locomotive requiring class Three repairs and scheduled to be completed within 24 days. It will be noted that each shop has its column wherein are listed the various parts of the locomotive handled by that shop. The figure appearing opposite each item is the scheduled number of days for the completion of each operation. For example; the figure two opposite "Engine Stripped" in the erecting shop column, indicated that the erecting shop is to have the locomotive stripped and material delivered two days after the engine arrives in that shop.

SCHEDULE FOR 24 DAY LOCOMOTIVE

Erecting shop	
Eng. stripped	2
Boiler off	4
Cyl. stripped	4
Frame Bolted	18
Shoes and wedges laid off	15
Boiler Mounted	18
Boiler fittings applied	16
Dry pipe in	16
Cyl. bushings in or bored	18
Valve bushings in or bored	18
Boiler tested	19
Guides and crossheads up	20
Boiler lagged and jacketed	20
Engine truck O. K	19
Engine wheeled	20
Motion work up	21
Sup'heater units appl. & st. pipe	22
Valves in and out	22
Main and side rods on	23
Brake rigging applied	22
Cab and cab work applied	23
Pipes O. K	24
Ash pan and grates O. K	23
Tender coupled to engine	24
Engine out	24
Frames	—

Machine shop	
Cylinders	15
Frame braces and pads	16
Boiler fitting	14
Shoes and wedges for laying off	13
Cyl. bushings	17
Valve bushings	17
Guides and crossheads	18
Driving boxes	18
Motion work	19
Shoes and wedges	19
Pistons	19
Valves	19
Main rods	21
Cab work	21
Side rods	21
Air brake equipment	21
Driver brake rigging	20
Tender parts	19

Boiler shop	
New fire box	
Flues applied	18
Boiler tested	19
Ash pan O. K	23
Tender O. K	22

Forge shop	
Frames	
Binders	14
Motion work	8
Spring Rigging	19
Main and side rod	7
Brake rigging	11
Eng. tank parts	14
Tender parts	19

Wheel shop	
Engine truck, wheels and boxes	17
Driving wheels and boxes	17
Tender truck, wheels and boxes	19

Pipe and jacket shop	
Jacket O. K	21
Pipes O. K	24
Cab O. K	22

Tender shop	
Tender parts	20
Tender trucks and frame O. K.	21
Cistern O. K	22
Tender O. K	23
Tender coupled to engine	24

Fig. 3. Schedule for a Locomotive to be Completed in 24 Days

The class of repairs, and number of days in which to complete the repairs having been determined, the next step is to inform the various shop foremen when the various operations

in their respective shops are to be completed. This is accomplished by the use of a repair card, shown in Fig. 4. This repair card is compiled by the route clerk and distributed to the various shop foremen concerned. Using the master

MACHINE SHOP REPAIR CARD.

Issued to........ ....Foreman

Engine No........................
S. O. No........................
Date in, 10-28-18
Date out, 11-30-18

Class of work	Wanted from erect shop	Wanted in erect shop	Wanted in smith shop	Wanted from smith shop	Wanted from tank shop	Wanted in tank shop
Engine frames	....	....	....	....	....	....
Side rods	10-29-18	11-21-18	11- 1-18	11- 5-18	....	....
Frame braces and pads	10-29-18	11-15-18	....	....	....	....
Boiler fittings	10-29-18	11-13-18	....	....	....	....
Cylinder bushings	....	11-16-18	....	....	....	....
Valve bushings	....	11-16-18	....	....	....	....
Guides and crossheads	10-29-18	11-18-18	11- 1-18	11- 4-18	....	....
Driving boxes	10-29-18	11-18-18	....	....	....	....
Motion work	10-29-18	11-19-18	11- 4-18	11- 7-18	....	....
Shoes and wedges	10-14-18	11-19-18	....	....	....	....
Pistons and valves	10-29-18	11-19-18	....	....	....	....
Main rods	10-29-18	11-21-18	11- 1-18	11- 5-18	....	....
Cylinders	11- 1-18	11-14-18	....	....	....	....
Cab work	10-29-18	11-21-18	....	....	....	....
Air brake equipment	10-29-18	11-21-18	....	....	....	....
Engine brake rigging	10-29-18	11-20-18	11- 2-18	11- 9-18	....	....
Engine truck wheels	10-29-18	11-16-18	....	....	....	....
Driving wheels	10-29-18	11-16-18	....	....	....	....
Tender wheels	....	....	....	....	10-29-18	11-19-18
Tender parts	....	....	....	....	10-29-18	11-19-18
Tender brake cylinders	....	....	....	....	10-29-18	11-19-18

Fig. 4. Typical Form of Date Shown on Machine Shop Repair Card

sheet as a guide, showing the number of days in which each operation is to be completed, the repair card is compiled to show the day of the month on which each operation is to be

ERECTING SHOP REPAIR CARD

Engine No.............................
S. O. No.............................
Date In 10-28-18
Issued to ....Foreman. Date Out 11-30-18

Class of work	Date wanted	Class of work	Date wanted
Engine stripped and material delivered	10-29-18	Engine truck O.K.	11-19-18
Boiler delivered to boiler shop	11- 1-18	Engine wheeled	11-20-18
Boiler in shop mounted.	11-18-18	Motion work up	11-21-18
Frames Bolted	11-18-18	Superheater units appl and steam pipes O.K.	11-22-18
Cylinder stripped	11- 1-18	Valves in and set	11-22-18
Shoes and wedges laid off	11-14-18	Main and side rods on.	11-23-18
Boiler fittings applied	11-15-18	Spring rigging O. K.	11-19-18
Boiler test (water)	11-19-18	Brake rigging applied O. K.	11-22-18
Boiler test (steam)	11-20-18	Pipes O. K.	11-24-18
Cylinder bushings in or bored	11-18-18	Ash pan and grates O.K.	11-23-18
Valve bushings in or bored	11-18-18	Cylinder welded	....
Guides and crossheads up	11-20-18	Flat spots welded	....
Boiler lagged	11-20-18	Engine out	11-24-18
Boiler jacket O.K.	11-21-18		

Fig. 5. Erecting Shop Repair Card

completed. Fig. 4 is the repair card for the machine shop and it will be noted that there is listed thereon the date each part is to be received from another shop and also the date

BOILER SHOP REPAIR CARD

Eng. No..........
Date In. 10-28-18
S. O. No..........
Issued to .... Foreman. Date Out, 11-30-18

Class of work	Wanted in erect shop	Wanted from erect shop	Wanted from tank shop	Wanted in Tank Shop
New fire box..	....	....	....	....
Flues applied..	11-18-18	....	....	....
Boiler tested..	11-19-18	....	....	....
Ash pan O.K.	11-23-18	....	....	....
Steel run boards O.K..	11-15-18	11-1-18	....	....
Tender tank O.K.	....	....	11-22-18	....

Fig. 6. Boiler Shop Repair Card

that it is to be completed and passed on to the next shop concerned.

Similar repair cards are furnished the various other shop foremen, Fig. 5 showing the form for erecting shop, Fig. 9 for the smith shop, Fig. 6 for the boiler shop, Fig. 10 for the tank shop, Fig. 7 for the wheel shop and Fig. 8 for the pipe and welding shop. These repair cards enable each shop foreman to know at all times just what work he has ahead of him and by what date the various items must be completed so far as his shop is concerned, and passed on to the next shop for further work, and so on until completion, when the part will be returned to the erecting shop to be applied to the locomotive undergoing repairs, on such a date as to make it possible to get the locomotive out of shop on the scheduled date.

As a ready method of arriving at the day of the month on

WHEEL SHOP REPAIR CARD

Eng. No..........
S. O. No.........
Date In, 10-28-18
Issued to .... Foreman. Date Out, 11-30-18

Class of work	Wanted from erect. shop	Wanted in erect. shop	Wanted from tank shop	Wanted in tank shop
Driving wheels	10-29-18	11-16-18	....	....
Engine truck wheels.	10-29-18	11-16-18	....	....
Tender wheels	....	....	10-29-18	11-19-18

Fig. 7. Wheel Shop Repair Card

which each operation is to be handled in the various shops from the master sheet, showing the number of days instead of the dates, as previously explained, a calender rule is used (Fig. 13). This rule has a slide through the center ruled

PIPE, JACKET AND WELDING SHOP REPAIR CARD

Eng. No..........
S. O. No.........
Date Out, 11-30-18
Issued to .... Foreman. Date Out, 11-30-18

Class of work	Work to be finished	
Boiler jacket	11-21-18	....
Pipes O. K.	11-24-18	....
Babbitt work finished	11-4-18	....
Cylinders welded	....	....
Cab O. K.	....	....

Fig. 8. Pipe, Jacket and Welding Shop Repair Card

off in squares numbered consecutively from 1 to 45 inclusive, 45 days being considered the approximate maximum time a locomotive will remain in these shops. Above and below the slide are pasted sheets ruled in squares corresponding in size to the squares on the slides and numbered consecutively for each day of the month, Sundays and holidays eliminated. This rule provides for a three month period at one time, at the expiration of which, new ruled sheets for the next three months are placed on the rule taking the place

of the ones for the previous three months. By placing the slide so that number one is opposite the day of the month in which the locomotive was placed in the shop for repairs the date each operation is to be accomplished can readily be determined. For example, assume a locomotive arriving October 28, requiring class Three repairs, the scheduled date for which has been set at 24 days. Reference to the master sheet, Fig. 3, will show that the boiler fittings are to be applied within 16 days. By placing the slide so that number one will be opposite October 28, one will readily see that this operation must be completed on or before November 15.

In the general foreman's office a "Despatch Board" is located. This board is fitted with a slide rule, ruled off, a space being provided for each locomotive part, listed in the same order as it appears on the master sheet. Tacked to the board is tracing paper ruled off in squares corresponding in size to the ruling on the sliding rule. In the first column to the left are placed the dates of the month, Sundays and holidays excluded. When a locomotive is scheduled the route clerk enters the locomotive number on the despatch board in the square opposite each item to be handled and the date on which each item is to be completed in the various shops. For instance in the case we have considered throughout this explanation, the boiler fittings of this locomotive are to be applied by November 15. In posting the despatch board the slide rule will be placed on a line with the fifteenth day of the month, and in the square parallel with "Boiler Fittings" will be placed the locomotive number. Should it occur that a locomotive part is not completed by the date it is scheduled for completion, the number is carried forward in red ink to the next day and so on until the operation is complete.

BLACKSMITH SHOP REPAIR CARD

Engine No.........................
S. O. No.........................
Date in 10-28-18
Date out 11-30-18

Issued to .... Foreman.

Class of work	Wanted from Mach shop	Wanted in mach. shop	Wanted from erect. shop	Wanted in erect. shop	Wanted from tank shop	Wanted in tank shop
Engine frames	....	....	....	....	....	....
Frame binders	....	....	11- 1-18	11-13-18	....	....
Motion work	11- 4-18	11- 7-18	....	....	....	....
Spring rigging	....	....	11-29-18	11-19-18	....	....
Main and side rods	11- 1-18	11- 5-18	....	....	....	....
Engine brake rigging	11- 2-18	11- 9-18	....	....	....	....
Engine truck parts	....	....	11- 1-18	11-13-18	....	....
Tender parts	....	....	....	....	11- 1-18	11-19-18
Guides	11- 1-18	11- 5-18	....	....	....	....

Fig. 9. Blacksmith Shop Repair Card

TANK SHOP REPAIR CARD

Eng. No...........
S. O. No..........
Date In, 10-28-18
Date Out, 11-30-18

Issued to .... Foreman.

Class of work	Wanted in tank shop	Wanted for engine	Wanted in machine shop	Wanted from machine shop	Wanted in smith shop	Wanted from smith shop
Tender	10-28-18	11-30-18	....	....	....	....
Tender trucks and frame O. K.	11-21-18	....	....	....	....	....
Cistern O K	11-22-18	....	....	....	....	....
Tender wheels	....	....	10-29-18	11-19-18	....	....
Tender parts	....	....	10-29-18	11-19-18	11-1-18	11-9-18
Engine truck O. K.	....	11-19-18	....	....	....	....

Fig. 10. Tank Shop Repair Card

ERECTING SHOP OPERATION CHECK LIST

.... 19..

Engine No.	Operation	Cause of delay
......	Engine stripped and material delivered.	....
......	Boiler delivered to boiler shop..	....
......	Boiler in shop mounted........	....
......	Frames bolted	....
......	Cylinder stripped	....
......	Shoes and wedges laid off.....	....
......	Boiler fittings applied..........	....
......	Boiler test (water)............	....
......	Boiler test (steam)............	....
......	Cylinder bushings in or bored..	....
......	Valve bushings in or bored....	....
......	Guides and crossheads up......	....
......	Boiler lagged	....
......	Boiler jacket O. K............	....
......	Engine truck O. K............	....
......	Engine wheeled	....
......	Motion work up..............	....
......	Superheater units applied and steam pipes O. K.	....
......	Valves in and set.............	....
......	Main and side rods on.......	....
......	Spring rigging O K...........	....
......	Brake rigging applied O. K....	....
......	Pipes O. K..................	....
......	Ash pan and grates O. K......	....
......	Cylinders welded	....
......	Flat spots welded.............	....
......	Engine out	....

Fig. 11. Form for Checking Operations in the Erecting Shop

MACHINE SHOP MATERIAL CHECK LIST

.... 19..

Engine No.	Days late	Material	Where due	Remarks
......	......	Engine frames and parts..	E.S.	....
......	......	Cylinders	E.S.	....
......	......	Boiler fittings	E.S.	....
......	......	Cylinder bushings	E.S.	....
......	......	Valve bushings	E.S.	....
......	......	Guides and crossheads...	E.S.	....
......	......	Driving boxes	E.S.	....
......	......	Motion work	E.S.	....
......	......	Shoes and wedges........	E.S.	....
......	......	Pistons and valves.......	E.S.	....
......	......	Main rods	E.S.	....
......	......	Side rods	E.S.	....
......	......	Cab work	E.S.	....
......	......	Air brake equipment.....	E.S.	....
......	......	Engine brake rigging.....	E.S.	....
......	......	Engine truck wheels......	E.S.	....
......	......	Driving wheels	E.S.	....
......	......	Tender wheels	T.S.	....
......	......	Tender parts	T.S.	....

Fig. 12. Machine Shop Material Check List

This despatch board enables the general foreman to tell at a glance just what locomotive parts are due for completion on any certain day, and indicates to him and others concerned, just what parts are delaying the completion of the locomotive in the erecting shop.

Each morning the route clerk refers to the despatch board and determines therefrom what operations should have been completed at the close of the previous working day and enters on a check list the locomotive numbers opposite each item that should have been completed. The check lists used for the erecting shop, machine shop, for all other shops, are

shown in Figs. 11, 12 and 14 respectively. The route clerk then visits the various shops determining whether or not the operations have been completed. If completed a line is drawn through the locomotive number. If not completed, an explanation and the prospective date of completion, are secured from the foreman in charge of the shop wherein the delay has occurred and this information is entered on the check list in the column headed "Cause of Delay" or "Remarks." When this morning check has been completed reports are rendered to the general foreman, on the form in Fig. 15, showing delayed operations in the erecting shop, and Fig. 16, showing delayed operations in all other shops. These reports place the general foreman in a position to know what work is being delayed or likely to be delayed, and his investigation can be instituted in sufficient time to cause action to be taken that will bring about the completion of the locomotive on the scheduled date.

This system of routing and scheduling had decided advantages over the former system, and brought about very beneficial results, the most important result obtained being that for which the system was originated, namely, the elimination of holding locomotives in the shops past their scheduled date.

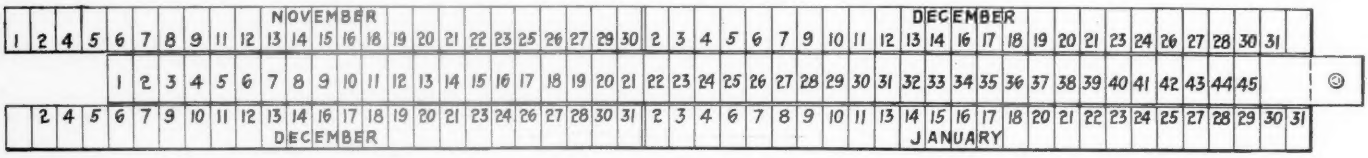


Fig. 13. Calendar Rule for Scheduling Work

Blacksmith, Boiler, Tank, Pipe, Jacket and Cab Shops Material Check List

.... 19..

Engine No.	Days late	Material	Where due	Remarks
......	......	Engine frame	M.S.	....
......	......	Frame binders	E.S.	....
......	......	Motion work	M.S.	....
......	......	Spring rigging	E.S.	....
......	......	Main and side rods	M.S.	....
......	......	Eng. brake rigging	E.S.	....
......	......	Eng. truck parts	E.S.	....
......	......	Tender parts	T.S.	....
......	......	Guides	M.S.	....
......	......	New fire box	B.S.	....
......	......	Flues applied	E.S.	....
......	......	Boiler tested	E.S.	....
......	......	Ash pan O. K.	E.S.	....
......	......	Steel run. boards	E.S.	....
......	......	Tender tank O. K.	T.S.	....
......	......	Tender O. K.	T.S.	....
......	......	Tender due for eng.	E.S.	....
......	......	Jacket O. K.	E.S.	....
......	......	Pipes O. K.	E.S.	....
......	......	Cab O. K.	E.S.	....
......	......	Babbitting finished	P.S.	....
......	......	Cylinder welded	E.S.	....

Fig. 14. Miscellaneous Shop Checking List

.... 19..

General Foreman.

Note statement of Erecting Shop operations late to date:

Eng. No.	Operation	Days late	Cause of delay
....	....	....	....
....	....	....	....
....	....	....	....

Fig. 15. Form for Reporting Delays in the Erecting Shop

.... 19..

General Foreman.

Note statement of finished material late in delivery to date:

Eng. No.	Material	Where delayed	Days late	Cause of delays
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

Fig. 16. Form for Reporting Delayed Material

TRACK STOPS FOR ROUNDHOUSES

BY NORMAN MAC LEOD

It frequently happens, due to carelessness or poor judgment on the part of railroad employees, that locomotives are run too far in a roundhouse or other points in railroad shops or yards, resulting in the locomotive being derailed or in damage to the buildings. To overcome this trouble two designs of track stops have been put in use in a number of roundhouses on one of the larger railroads and have proved very effective. The material used for both of these stops is cast steel.

The stop shown in Fig. 1 is made in right and left hand

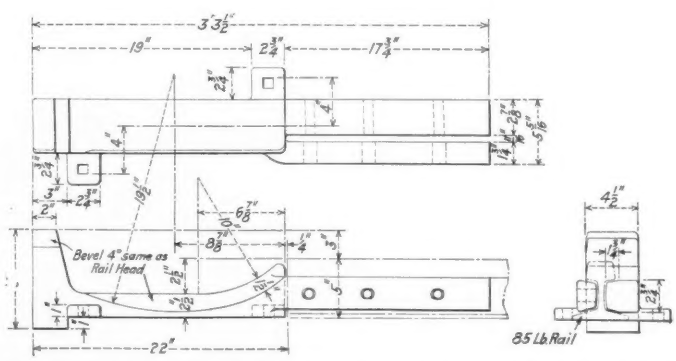


Fig. 1. One Piece Track Stop for Application at the End of the Rail

patterns, and is intended for use at the end of a track. It is provided with an extended concave portion to receive the wheel and stop the locomotive should it be run too far. The other type of stop, as shown in Fig. 2, is made in two parts,

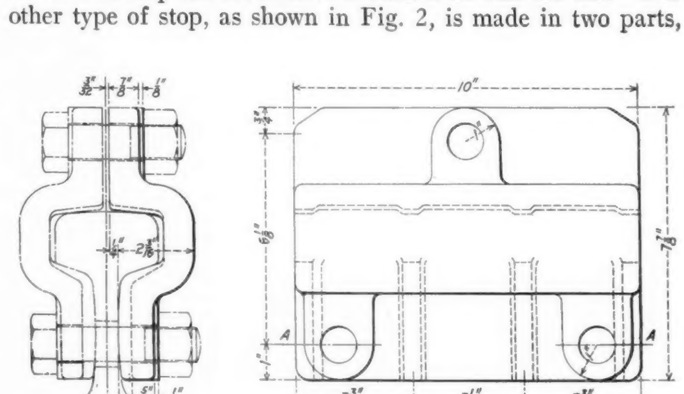


Fig. 2. Two-Piece Track Stop for Application at Any Point on the Rail

which are bolted to and project above the rail head. It can be applied to the rails at any point that may be desired, even at the joint between two rails.

The use of such stops will prevent many expensive and dangerous accidents, and track stops made to these designs or other similar devices should be used wherever such trouble has been experienced.

Fools Rush In Where Angels Fear to Tread

The General Manager Gets Some Inside Dope on Causes of the High Cost of Locomotive Repairs

BY HUGH K. CHRISTIE

GIBBONS, the general foreman read and re-read the announcement. Reflectively he laid down the railroad magazine and stared vacantly at the red-lettered cover. His clerk eyed him curiously.

"Any local news along the line this month?" he finally asked as he pushed over Gibbons' mail.

"Nothing at Grand Falls," responded the boss, "but an article here has got me thinking. The general manager says he'll give a fifty dollar prize to any railroad employee who will send him direct the best write-up on savings in any department on the road."

"Why don't you give him some dope?" said Leary, the clerk. "You and me have been watching leaks every day around here for some years and now's your chance. Fifty dollars is fifty dollars you know."

Gibbons shook his head. "Don't pay, Leary," he replied. "If we knew as much about saving as the big fellows did why—why, we'd be on their jobs. You know how I get bawled when I start suggesting. I would like to tell them a few things, though," he added absently.

"And the fifty dollars, too," reminded Gibbons' understudy.

"Ain't the money," said the boss, "but I would like to poke up a hornets' nest around here and get some material. Say, save that magazine for my noon hour," he abruptly commanded—"I'm going to the store," and the foreman pulled on his hat and started through the shop toward the little office at the end of the long brick store building.

Gibbons gave no heed to what was taking place about him, as he swung down the pit-side. The general manager's announcement kept pounding in his brain. He did not care to tell Leary that the fifty dollars meant more to him than the voicing of his protest against inefficient performance. He wanted those fifty iron men and wanted them badly. Wasn't he going to the community dance in a week and wouldn't he have to be all dolled up? Fifty dollars would do the trick nicely without cutting a hole into his two weeks' check. The idea was how to go about it, for William Gibbons was no hand to produce exploded verbal kicks in polished written form for a G. M. to read.

He swung open the door to find the storekeeper in conference with a visitor, who was recognized at once by the sharp-eyed boss. It was Case, the general storekeeper.

"How are you, Mr. Gibbons," he said as he reached for Bill's hand. The enthusiasm, however, was all on his side. With a gruff, "howdy" the foreman turned his attention to the storekeeper.

"Say," he announced, "we're all out of D. S. 5 springs for Engine 397. She was due out tomorrow—I've got her wheeled and blocked waiting for 'em."

The storekeeper looked wearily at Gibbons and then turned toward his own boss for some suggestion.

"Hear about this before?" asked the general storekeeper.

"Yes," replied the local man. "I wired to Sagum Hill but didn't get an answer."

The general storekeeper looked toward the frowning foreman. "Why—why don't you get some out of the scrap."

"I knew it!" exploded Gibbons. "All I hear around here is, 'Look in the scrap!' Good Lord! what you fellows doing these days? Running the store department on scrap! Say, I got a limited pay roll on labor and I ain't got no time to waste hunting scrap."

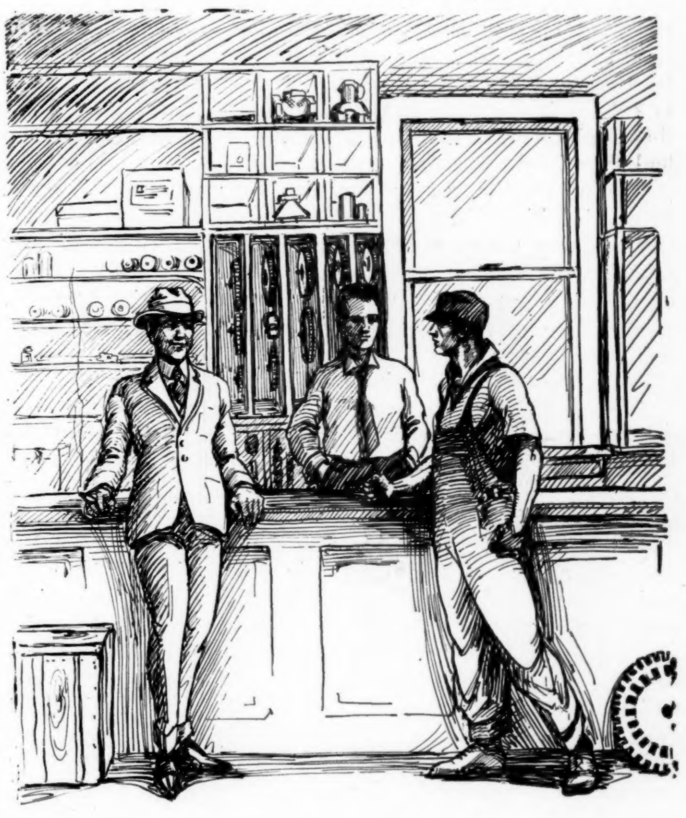
The general storekeeper laughed easily.

"Don't get excited, Mr. Gibbons," he remarked. "We have got our limits to work inside, ourselves. The proportion must be maintained, you know."

"Proportion! What proportion?" growled the shop foreman.

"The proportion between material and labor in railroading," smoothly responded the general storekeeper as he relit his half consumed cigar and regarded Bill, the foreman, complacently.

"You see it's just like this," he continued, noting Gibbons' blank look. "Material should run about 40 per cent and labor 60 per cent on your cost of back shop repairs. At the present time we are maintaining our figures, but the mechanical department has gone way beyond theirs. From this it is evident that the store department is more efficient than



"We're All Out of D. S. 5 Springs for Engine 397."

your department, and that is why I suggested that you look the scrap pile over for waste of material."

The local storekeeper expected one of Bill's daily brain storms over shortage of material but none was forthcoming. In silence Gibbons rubbed his chin and stared reflectively at the visitor.

"Those the customary figures?" he finally questioned.

"They certainly are," responded Case. "Any complaint against them?" he added.

"Don't know," remarked the shop boss thoughtfully. "I do know one thing, however, and that's this: The store department always makes a hit when it cuts down material no

*Entered in the Railway Mechanical Engineer prize story contest.

difference how it affects the mechanical department, which can't squeal because it has always been considered the non-revenue end of the pike. My boss is trying to save money by getting more material and your boss, the purchasing agent, is cutting requisitions. If it comes to a show down the store wins out.

"You store fellows are always talking about saving and reclaiming scrap," continued Bill, "but I say, why don't you get decent material that won't have to be scrapped. We order one thing and get something else."

The general storekeeper blew out a puff of smoke and grinned.

"Better tell the general manager about these things, Mr. Gibbons, and see who is right," he finally remarked.

For a solid minute the shop boss stood staring vaguely beyond the speaker. Evidently the general storekeeper had not seen the announcement in the magazine. Suddenly Gibbons started for the door. As he started to close it he turned first to the storekeeper. "Chase those springs, Bill?" he requested. Then a sharp glance toward Case. "Thanks for your advice you gave me a second ago—believe I will give the G. M. a few tips." Without another word he disappeared.

Gibbons went through the rest of the working day automatically. No one noticed that he acted peculiarly different, but his clerk appeared surprised when Gibbons asked him to get the cost sheets for overhauling back shop locomotives by months for the past year. Leary was further puzzled to see his boss carefully roll up the data and take it home that night with a mass of notes which the under foreman had submitted.

Throughout the evening meal the boss was unusually quiet. It worried his wife.

"Anything wrong at the shop today, Bill?" she anxiously asked.

"Nothing out of the usual, Peggy," came the response. "But I'll be busy on some work tonight and I'm just checking it off in my brain."

"Is it for the shop?" she questioned.

A grim smile came over her man's face. "Maybe, and maybe not—maybe I'm digging my own grave, but what I'm figuring on doing is writing the general manager for a suit of clothes. I'll either get them or get something else that I ain't looking for."

Bill would not satisfy his wife by answering any other question, and as soon as the dishes were cleared from the table he produced his railroad papers. Patiently he worked over locomotive costs of heavies and lights. He had repairs running from five hundred to four thousand dollars. Carefully he separated the labor and material costs grunting astonishment at his results. He whispered an oath at the final averages.

In repairing power *90 per cent represented labor and only 10 material.* On a $2,000 repair job only $200 was used for material. Gibbons discovered that on a basis of 40 per cent for material and 60 per cent for labor $500 should be the proper labor charge. Instead, it was $1,800. It was $1,300 too much.

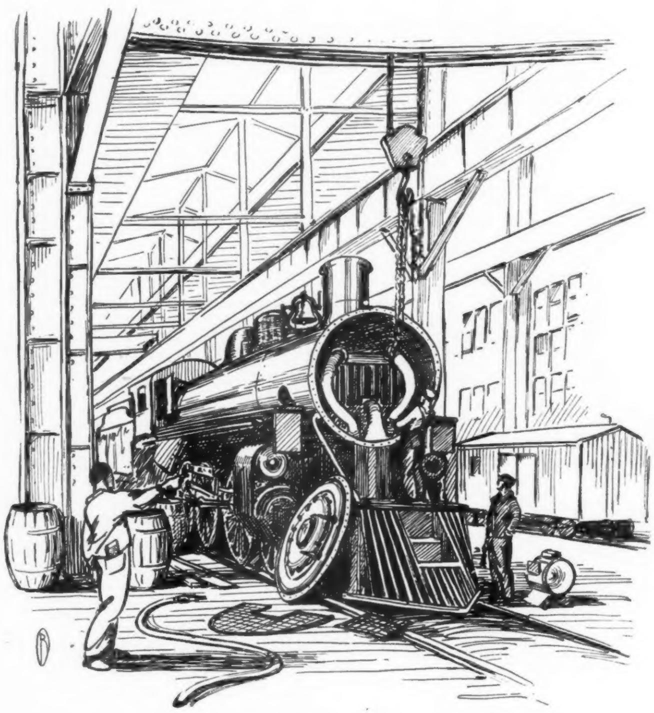
Then he began going over the work sheets. He picked out scores of places where new material should have been used but on account of none being in stock, other engines were robbed or expensive reclaiming was followed.

At one time a consolidation engine required a left steam pipe. An engine waiting shop had been robbed for a pipe although its front end required but minor repairs. The front end and netting were removed. The petticoat pipe was disconnected and the steam pipe joints broken for the sake of this pipe needed for the engine going out. It required over $100 worth of labor to apply the new pipe which would not have been removed if material had been in stock.

Gibbons groaned as he remembered disconnecting crossheads and pulling down guides for back cylinder heads from good engines, in order to rush back shop repairs. In the majority of cases, the store shortage had cost him hundreds of dollars.

He had made forgings that cost many days work for the lack of castings. He got together the figures representing wasted labor looking over the scrap pile. He then added the cost of reclaiming. Gradually his data disclosed the fact that the engine which cost approximately $2,000 for repairs could have been repaired for $1,000 if $400 had been used for material instead of $200. To get the other $200 worth of material he had spent over a thousand dollars in labor.

It seemed incredible. Gibbons knew that this was a heavy



They Had to Rob an Engine to Get a Left Steam Pipe

repair but his light repairs brought out the same approximate proportion.

All excitement the general foreman started his letter to the general manager. It was a long hand affair with a mass of figures taken from the official report. In it were typical illustrations—in other words, actual evidence. At the end of the article the foreman wrote as follows:

"Mr. Corey, if you went to a shoe store and asked for a pair of shoes, what would you think if the clerk said: 'We are entirely out of shoes, but we have some nice leather boots. They cost twice as much but they are your size. You can cut the tops off and throw the unused parts away. Otherwise, I guess you must go without unless I wire for some and I know you can't wait!' Now this is the fix the mechanical department is in, Mr. Corey. We must butcher up good stock or do without. Years ago material was cheaper than labor, but today the reverse holds true. I do not believe in waste, but unless you get your store figures up to 40 per cent of your figures of repair there is going to be a big waste in spite of the best care along lines of supervision."

The foreman signed his letter with a sprawling William Gibbons and then added his title. He then re-read the article in the magazine. It said to send the article direct to the general manager. Gibbons inserted the letter in a railroad envelope. He pulled on his shoes and started for the drug store for a stamp. The boss did not intend to have his information side tracked by going through the railroad mail.

"Ten and ninety, eh, instead of forty and sixty? Somebody's going to get their eyes opened. If they open right I get my suit of clothes—and if they open wrong I guess I'll have to look for another job." With these words on his lips William Gibbons went to sleep.

Gibbons slept late the next morning and his better half did not have time to question him. By evening she had forgotten the whole affair. Not so with Bill. All day long vague misgivings seized him. Had he done right in pursuing this course? Collings, the purchasing agent, stood very close to the general manager. It had often been said that the man who forced an issue with Collings was bound to get it, using a shop phrase, "in the neck." The day went by without a hitch, however, and the shop superintendent and master mechanic seemed unusually cheerful.

Next day trouble appeared on the horizon—about noon to be exact. The shop efficency man had got back from headquarters on the ten o'clock train and went into the master mechanic's office immediately. Then the shop superintendent was called and finally Shop Foreman Gibbons.

It was a chilly atmosphere that the shop boss struck in the master mechanic's office. He was asked to be seated and the inquisition was on.

"William," began the master mechanic. "Gordon has just come from the superintendent of motive power, and he tells us strange things. The big boss told him that the general manager, had called him up asking about a shop foreman by the name of Gibbons, who had given him some dope on savings. Wanted to know what kind of a fellow you were. Now the big boss held back on recommending you very highly until he knew what you had written, and, although all of us here have thought pretty well of you, we no doubt have been mistaken in you if you are making a practice of taking things over our head." The master mechanic gazed sternly at the shop boss as he spoke.

The efficiency man grinned at Bill's abashed face. There was no love lost between them.

"Spit her out, Bill," broke in the shop superintendent.

The general foreman hesitated a moment and then began. "Yes, I wrote him all right and told him one of the best ways of saving money around this plant."

"Why did you do that?" asked the efficiency man.

"Because he asked me to," returned Gibbons.

"Asked you to!" exclaimed the master mechanic.

Bill slowly reached in his back pocket and produced the railroad's magazine.

"Read it," he said. It was passed from man to man. None of them had noticed the article before.

"I ain't carrying anything over anyone's head," began Bill stoutly. "This was no regular railroad business."

"But you should have at least let us see it," returned the master mechanic. "Why didn't you let us read it first?"

When Gibbons was cornered he welcomed a fight. "Well, I'll tell you," he flared up, "why I didn't. Before anything like that would pass this here board of censorship there wouldn't be much left."

The efficiency man glared at the foreman's remark but the eyes of the master mechanic looked cold as ice.

"You would certainly condescend to show us a copy of the letter for the sake of the men you work for, wouldn't you?" he asked sarcastically.

Gibbons shook his head in the negative.

"It can't be done 'cause I wrote it longhand and never saved a copy."

"Then kindly tell us what you said," demanded the master mechanic.

Gibbons gave a detailed account of the letter. The jaws of his listeners dropped at the freedom of expression.

"Did you tell him all that?" gasped the shop superintendent.

"Yes, and maybe some more," returned the general foreman. "It's the truth, ain't it?"

For several moments the master mechanic sat and stared at Bill. Could this be his easy-going foreman?

"Gibbons," he finally announced, "you have got more gall than a young hogger. You should have realized that the general manager published this article to excite an interest and a spirit of co-operation; and here you unload a stick of dynamite. Of course, I can see why you sent your article in direct, but you have given us but very little protection, and if the worst comes why we simply can't save you."

"Collings, the purchasing agent, has been a thorn in our flesh and also the boss's for a long time, but he stands so close to the general manager that no one has dared to produce the facts. Now re-write the thing out to the best of your memory and shoot it up here for typing, and hurry."

Obediently Gibbons arose and left the room. In silence the three remaining men stared at each other. "I'm afraid he's in bad," absently remarked the master mechanic, "even if he did tell the truth but—but Lord what gall!" he added.

The general foreman's second letter was turned in—a copy was hurried to the superintendent of motive power. The rest of the day went badly for the poor fellow. Every thing seemed to go wrong. He received vacant stares from his bosses. "Just about as welcome as a head full of bugs," he mournfully remarked to himself.

His wife sensed his depression as soon as he arrived home that night. He confided his troubles and finished by saying:

"I'm in bad, Peggy—the gamble wasn't worth it—I played

"I'm in Bad, Peggy."

for a suit of clothes and will probably get the bounce." All night long he dreamed of a fifty dollar bill chasing a suit of clothes, both being run down by Collings, the purchasing agent.

The morning of the next day was a repetition of the previous day's misery. That is, it was until the master mechanic got his mail. Another call came for Gibbons to report to the office. Indifferently the general foreman responded. He was callous to additional trouble. He entered the doorway. It was the same room and the same faces but the atmosphere was different. Had Gibbons been more alert he would have caught the difference.

Again he was asked to be seated. The master mechanic

was holding an opened letter in his hand with a green slip attached to it.

"Gibbons," announced the master mechanic in a stern voice but with a hidden twinkle in his eye, "I just got a copy of a letter from the general manager to the superintendent of motive power. He says some awfully nice things about you which you can read later on. Says he had been misinformed in the past and that from now on more attention would be paid to getting material, and material which the mechanical department specifies will come as specified. Speaks about details taken up later along this line and mentions that he intended writing you a letter of thanks later on."

The master mechanic was now smiling broadly. "Here is a letter from the superintendent himself. He wants to know if you can be trusted with the job of mechanical inspector. Tells me that that fellow Gibbons must have some kick in him when he dares to tell the truth."

The master mechanic's eyes fell again on the original letter. "Oh, yes, by the way, my copy from the general manager has your check for $50. You see, you got the prize. Your nerve ought to get you to the top of the ladder, my boy, and I admire your spirit, but I wouldn't get in the habit of going much higher than your next officer in passing information, because it don't pay."

The efficiency man slipped out. Bill received congratulations from the shop superintendent, and thanked the master mechanic for his words of advice.

"Honest, Mr. Good," he confessed to the master mechanic, "it wasn't nerve—I didn't know any better, and, to tell you the truth, I wanted that money for a suit of clothes."

The superintendent and his boss laughed heartily. "Better dig out early tonight, Bill, and pick 'em out," advised the superintendent. "You've done enough good around here to last for years." These were the parting words Gibbons caught as he left the office with an unconfined joy in his heart.

The two men remained sitting at the desk and watched the happy Bill swing toward the back shop doors down the lane of busy machines.

"How did he get by? Can you beat it?" remarked the superintendent of shops to his superior officer.

"Well, I first thought that it was because fools will walk where angels fear to tread, but I guess I'm wrong, because Gibbons has proved he's no fool, and I know tarnated well you and I aren't angels. Let's just say it was taking advantage of a literal interpretation and let it go at that. He's paved the way for getting us material. Got any one picked for his job after he gets his new position?"

Locomotive Repairs at Shop and Enginehouse*

Thoroughness in Back Shop and Attention to Slight Defects at Terminals Needed to Save Fuel

BY LESLIE R. PYLE
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Locomotive maintenance is one of the vital features of railroad operation. During the past two years, locomotives all over the United States have been turned so rapidly through terminals that a great many times needed repairs have been dispensed with. So far as one can see, there is no indication of a decrease in business; therefore, now is the time to take a definite stand for a better standard of locomotive maintenance.

The writer would urge for consideration and adoption, the standardization of the best practices for each piece of work to be done. Aimless effort however diligent will not produce the results that are possible through a well-defined plan and a standard by which to gage every effort. These standards should be blue printed, each print containing written instructions describing in detail how each job should be handled. This will insure every shop or drop-pit doing the work in the same manner. When a better practice is developed, the print should be changed to cover the improvement. If this is conscientiously followed, every shop will be doing the work in what is known to be the best way. Improved methods and practical short cuts are always acceptable and suggestions offered by anyone in any position should have thoughtful consideration. We should encourage men in subordinate capacities to give us their ideas and such ideas, when found to be practicable, should be adopted and the employee given the credit for the improvement.

Although it is realized that enginemen can and do waste fuel with locomotives in first class condition, it is obvious that the engineer will have no control over the fuel waste due to cylinders out of round, valve gear out of square, etc. When we consider that from 85 to 90 per cent of the total railroad fuel is consumed on the locomotive, there can be no doubt about the need for careful, painstaking preparation of the locomotive, first in the shop and then in the enginehouse.

Shop Maintenance

Naturally the shop is where the foundation is laid for preparation of the locomotive which will result in fuel conservation. Usually, when the locomotive enters the shop, it is accompanied by a work report showing what work is considered to be necessary. Too often when a locomotive is received in the shop, a council is held to determine just how little work can be done. This often results in work being neglected which should have been done in the shop, where the facilities tend to reduce the cost of every operation.

At present, but four to six per cent of the total heat developed is applied to the draw-bar in the form of useful work. Anything which tends to lower the efficiency of the locomotive is taken from the four to six per cent at the draw-bar and not from the 96 per cent total heat liberated in the firebox. This is why we lay such stress on the locomotive being thoroughly overhauled in the shop.

Bearing in mind that the power developed by the locomotive is produced in the firebox through the liberation of heat generated by the fuel when it is burned, we should consider the condition of the firebox and boiler when the locomotive is sent from the shop.

The firebox should be free from all steam leaks. Flues should be well set in the sheet so that there will be no trouble from flues leaking while the engine is in service. This also applies to welded flues.

Boiler sheets and tubes should be absolutely clean and free from scale. There should be enough well located wash-out plugs to enable boiler-washers to keep the sheets

*Abstract of a paper read before the Western Railway Club, January 19, 1920.

and tubes clean through the use of properly designed wash-out nozzles.

Grates and grate bars should be in good repair with well-designed shaker levers which will make the shaking of grates under service conditions a practical operation. A locking device should be provided to hold the grates level under the fuel bed, thus preventing holes in the fire and burnt-off grate fingers.

Arch tubes should be applied to locomotives not already equipped. It should be known that the ends of the tubes are beaded or belled sufficiently to provide against any possibility of the tube pulling through the sheet. These tubes should be thoroughly cleaned if dirty when reaching the shop.

The front end draft appliances should be installed according to a definite standard which has been arrived at as the result of road tests. These tests should have developed the practical setting for the petticoat pipe if one is used, the draft plate and the size of the nozzle tip, to insure a free steaming locomotive burning the average quality of fuel used. Blue prints should be furnished all shops and roundhouses, showing the standard front end setting and size of nozzle tip for each class of locomotive. Front end appliances should be set according to this print when engines are turned out of the shop.

The petticoat pipe should be well supported on hangers which hold it in a direct line with the smoke stack to insure the exhaust jet passing through the center of the stack. The joints between the base of the nozzle stand and cylinder saddle, and between the nozzle tip and the top of the stand, should be perfectly tight. Steam leaks at these joints materially affect the steaming qualities of a locomotive.

Steam pipe joints should be thoroughly ground in, insuring no leaks here.

The superheater should be applied according to blueprints furnished either by the superheater company or by the railroad company. If these prints are followed, no other directions should be necessary.

It is important that the joints of the superheater elements be thoroughly ground in. Heat treated bolts of high tensile strength and elastic limit should be used to bring the joints to a seat and hold them there. Suitable bands and bridges should be used to keep the elements from moving in the flues and to hold them up, making it possible to blow soot and cinders from beneath the elements. The damper should be applied in such a way that the correct opening will be obtainable and be securely fastened to the damper shaft to insure its positive operation.

If the stack or cylinders are changed while the locomotive is in the shop, the whole machine should be leveled up and the center of the nozzle tip plumbed with the center of the stack to insure the exhaust jet passing through the center of the stack. This should be emphasized because it is a common thing to find the exhaust jet out of line with the center of the stack.

Before the locomotive leaves the shop, a hydrostatic test should be applied, making a final inspection of all joints in the smoke box, a cap being placed over the nozzle tip when making the test. This may appear to be useless work, but it has been a common occurrence to find engines just out of the shop with steam leaks in the front end.

With draft appliances well arranged to provide draft through the boiler and the firebox, it becomes necessary to go below the mud ring to insure an adequate opening in the ash pan which will admit sufficient air to burn the maximum amount of fuel consumed under any working conditions. This should be an opening which will not clog up with cinders or with snow and ice in cold weather. An opening which is covered with netting is not satisfactory as it is too easily stopped up. There are a great many locomotives in service today lacking sufficient area of opening through the pan to admit air enough for complete combustion under normal conditions. Knowing this, we earnestly recommend that all locomotives be provided with the necessary amount of opening through the pan. This may involve radical changes in pan construction but the results obtained from such changes justify the expense.

Steam is used primarily to haul the train. Circular No. 19 sent out by the Fuel Conservation Section, illustrates in a striking way, the loss of fuel due to defective steam distribution. This circular brings out the fact that from 9.4 to 18.4 per cent of the steam was wasted due to distorted valve gear.

While the engine is in the shop, all pins and bushings in the valve gear should be renewed if they are worn at all. This brings to mind a statement of a roundhouse foreman in reply to a question asking why he was allowing a switch engine to remain at work when it was noticeably lame. He replied that the valves were only a little bit out. There is no little thing when considering the setting of valves and the elimination of lost motion through worn pins and bushings.

There should be a definite standard of valve setting for each class of locomotive. Valves should be set according to this standard before leaving the shop. If this is done carefully and all lost motion removed from the valve gear through the elimination of worn parts, we have made a good start towards the economical use of steam.

In the shop, if the wear in the cylinders is 1/16 in. or greater, they should be re-bored. Packing rings should be supplied which have been turned to compensate for the material taken out of the cylinders. If the valve bushing is worn 1/32 in. near the bridges, it should be re-bored and the necessary rings supplied.

A good plan to insure packing rings of the proper size is to have a definite standard of boring practice, a specified amount being taken out of the bushing each time it is bored and the cylinder packing rings turned and marked to correspond with the mark on the bored bushing. If this plan is followed, packing rings can be kept in stock to compensate for the bored bushing.

After taking care of the valves and cylinders, we should give the engineer every assistance in using the right cut-off while running the engine by putting the reverse lever and reach-rod up in such a manner that they can easily be handled. We can all recall locomotives which have been sent out of the shop with the reverse lever and reach-rod in such a condition that it required both the engineer and the fireman to handle the lever. This does not lead to co-operation from the man who has to operate the locomotive.

The power reverse gear should be overhauled at the same time the engine is. Reverse gears of this type should be as good as new when leaving the shop. There has been a great fuel waste through power reverse gears creeping and it has been found due to leaks in the operating mechanism, worn parts, allowing lost motion to develop, or through poor or worn packing.

Air compressors should be in good repair when placed upon the locomotive in the shop. All piping connected with brake equipment on the locomotive should be put up in such a manner that there are no air leaks. It has been found by tests that leakage as high as 15 lbs. per minute existed on the engine alone.

Steam used by auxiliary equipment amounts to six per cent of the total heat developed. This is why we stress the maintenance of such equipment as mechanical firedoors, bell ringers, headlight dynamos, steam grate shakers, cylinder cock operators, etc. All auxiliary equipment should be overhauled and tested in the shop to insure the maximum of good service from all devices. Headlight dynamos should

be well taken care of and all valves to the dynamo in good repair, making it practicable to close them to prevent leakage of steam.

Devices or valves which have to be operated by engineers and firemen should be, wherever possible, within easy reach of them to insure the efficient operation of the device. When men have to go out of their way to reach valves, the full value of the device is not always obtained.

Hot boxes waste more fuel than people generally realize. If a locomotive is delayed 30 minutes with a hot bearing on a busy piece of track, this delay is not confined to the one train and engine, but is passed on to numerous trains behind, the loss being cumulative. Special attention should be paid to the fitting of brasses and weight distribution on the axles to prevent hot boxes on locomotives.

Radiation losses on a locomotive amount to approximately five per cent of the total fuel consumed. A large portion of this loss may be prevented by thorough insulation. It is recommended that all steam pipes to air pumps, injectors, etc., be insulated with asbestoc from 1/4 in. to 1/2 in. thick, depending upon the amount of room around the pipe then covered with asbestos canvas, which in turn is covered with retort cement, thus making a weather and heat proof job. This applies to steam piping in the cab.

There is about 50 sq. ft. of uninsulated surface around the water legs of nearly all locomotives, which could be insulated with very little trouble to assist in preventing some of the per cent loss in radiation.

Stoker equipment should receive thorough attention while in the shop. One particular part of the stoker equipment which has caused considerable waste of fuel is the conveyor trough underneath the deck. When the conveyor is working, coal is pushed over the top of this trough and thrown on the ground. Inspection develops that this condition still exists and it should be eliminated.

An apparently simple matter but one which causes a waste of fuel, is the condition of the deck around the grate levers. It is common to find large holes around these levers through which coal is constantly lost while the engine is in service. In the first place, such holes should not be cut in the deck, but if they do exist, they should be covered with strips of metal.

Where the air pump exhaust is tapped into the smoke arch and goes out through the smoke stack, this connection should be changed to the exhaust passage in the saddle. There are two reasons for this: one is, that the exhaust passing through the front end creates a draft on the fire which cannot be controlled by the engineman and wastes considerable fuel; the other is, that as the air pump is usually working more or less, the exhaust from the pump will assist in relieving a vacuum in the exhaust passage when the throttle is closed and the train moving, which in turn reduces the amount of soot and gases drawn from the front end into the cylinders.

It will be impossible to touch on the general overhauling of the locomotive, but the parts and devices mentioned have been dwelt on because they have a direct influence on fuel consumption. It is true that they can be neglected and the engine will get over the road, hauling the train and apparently none the worse for the neglect. While it may not be visible in the operation of the locomotive, lack of repairs to these parts does waste fuel. As this waste is preventable and is no doubt many times greater than the cost of making repairs, we do not hesitate to recommend that such repairs be made.

It is easier to win when you are in the lead than to catch up when you get behind. The habit of starting early and starting right is not acquired by any sudden resolve. It must be built by careful practice and steady training—by conscientious study with the application of the best rules and regulations. Plan your work, then work your plan, making every play and every day a definite advance toward the goal, which should be 100 per cent locomotives.

Roundhouse Maintenance

In considering roundhouse maintenance, we must assume that the officer responsible for locomotive maintenance is allowed sufficient time to make necessary repairs. On nearly all railroads, the transportation officer often requires the turning of the power so rapidly that locomotives do not receive needful repairs. One superintendent told at a division fuel meeting that he was running his engines until the stack fell off and the bell rolled over into the field. In starting engines out in this condition, he realized that they were not fit to go but gambled that they might make a successful trip. His testimony was that he often had to send a second engine to get the first one in.

Sooner or later, locomotives have to be repaired, and under the present operating conditions we cannot look forward to a slump in business which will make it possible to hold power in the roundhouse long enough to do work on them which has accumulated. If the mechanical officer is successfully to maintain the locomotive in condition for economical and successful service, "the stitch in time" rule must be put into effect. This means that repairs have to be made as the need for them develops. He should be the judge of when a locomotive is fit to leave a roundhouse ready to make a successful trip. Often locomotives are hurried out and fail, necessitating the use of a second engine which many times has to give up a train of inferior class to take a superior train to a terminal. Such practices cause delays and congestion on the railroad and could be avoided generally if locomotives received necessary repairs.

As in the shop, we will consider the maintenance of the boiler and firebox as the first consideration. The boiler should be kept clean by frequent and thorough washings, preferably with hot water. It is generally accepted that hot water wash-out plants materially reduce the time required to wash boilers and by using waste steam to heat the water used for washing and filling, a direct fuel saving is accomplished.

It is important that sufficient pressure be used, with nozzles so designed that the water will reach all parts of the boiler. With well located wash-out plugs, it will then be possible to thoroughly clean the boiler at each wash-out. This, of course, implies that where water contains scale-forming elements, some form of water treatment be used.

In a paper by A. N. Willsie, read at the International Railway Fuel Association meeting, May 15, 1916, he shows a table giving the loss of heating power due to scale as follows:

"There seems to be a variance of opinion as to the losses due to the accumulation of scale in boilers. Some of the best authorities give the losses as about as shown in the following table:

APPROXIMATE LOSS OF HEATING POWER DUE TO SCALE

Thickness of scale, in.	1/64	1/32	1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4
Per cent loss of heating power	2	4	9	18	27	38	48	60	74	90

"These figures are not considered absolutely accurate as these losses are not found to occur in all boilers because the whole of the boiler surface does not usually become covered; still the loss is always serious, apart from the stresses set up in the boiler plates.

"The test made by Mr. Breckenridge of the University of Illinois, on a Mogul freight engine, which had been in service for 21 months, is recorded in the *Railroad Gazette*, January 27, 1899, page 60. This engine was tested, then sent to the shops and new flues installed, then tested the same as before. In order to get the average thickness of

scale, it was entirely removed from the tubes and weighed. This thickness gave an average of 3/64 in. on the principal heating surface and the loss in heating power due to the scale was 9.55 per cent."

It is evident that there is a decided loss in heat transmission when boiler sheets are allowed to accumulate a scale deposit. Water treatment and thorough boiler washing will practically eliminate scale from locomotive boilers in any kind of water. When boilers are kept clean it is comparatively easy to maintain the flues free from leaks.

There should be an inspection of the flues each trip and where necessary, they should be calked, or expanded and calked, depending upon the practice standardized on each railroad. Where flues are welded in, welding outfits should be maintained at terminals so that when the welds break, they can be re-welded. Firebox leaks, even though they do not cause failures, waste fuel, and where locomotives are allowed to run with flues in a condition that causes failures or near-failures, an excessive amount of fuel is consumed per trip. Flues which will not permit a successful trip should be changed.

Grates should be renewed when fingers are broken or burnt off and grate bars should be well maintained, insuring a perfect support for the grate sections. Grates should shake freely. To make this possible, grate levers and rods should be kept in good working condition. Grate fingers should not bind. Any neglect in the maintenance of any part of the grates or shaking apparatus tends to discourage the intelligent use of grates by engine crews and on this account should be thoroughly maintained. Steam grate shakers should be kept free from steam leaks at all joints in the piping and the grates otherwise maintained the same as with manually operated grates.

Frequent inspections should be made in the front end. The front end inspector should have someone on the outside open and close the superheater damper and actually see that the damper opens full width, not moving on the damper shaft. Where engines are equipped with petticoat pipes, the pipes should be renewed when worn and set to insure exhaust jet going out the center of the stack. Inspection should show that the locomotive still has the standard size nozzle with which it came from the shop.

When reports are made that the engine does not steam, do not make any change in the draft appliances. The steam pipes should be subjected to a hydrostatic test to determine whether there are any leaks in the superheater elements or return bends, steam pipes, at the base of nozzle stand, or at the base of the nozzle tip. If everything is tight and set to the adopted standard, someone should ride the engine to locate the trouble. Find the real trouble; do not change appliances or reduce the nozzle, except for weather or special fuel conditions.

It should be known by inspection that flues, both on superheated and non-superheated locomotives are kept clean. Nearly all roads have flue cleaning organizations but it has been found necessary to check up the work of these men to insure their doing it thoroughly. The Fuel Conservation Section has issued circulars showing the loss in fuel due to stopping up of large flues on superheated locomotives. This loss varies as shown on the following table from Circular 16:

Number of superheater flues stopped up.	Average temperature of steam (deg. F.)	Drop in temperature below 586 deg. F. (deg. F.)	Superheat (deg. F.)	Fuel loss (per cent.)
None	586	..	211	.....
5 to 7	576	10	201	0.04 to 2.6
8 and 9	549	37	174	6.0 to 9.6
12	517	69	142	13.2 to 14.6
18	491	95	116	21.0 to 24.2

If, for any reason, valves become out of square through lost motion in the valve gear or accident, they should be squared up immediately.

Cylinder and valve rings should be renewed when necessary to prevent blows, which are exceedingly wasteful of steam and materially affect the hauling power of the locomotive. Many roads have adopted a 30-day inspection of cylinder and valve rings. Such inspection develops many worn rings which would not be reported. This practice is recommended for consideration by roads not doing it. If an engine has been out of the shop for a long time and the cylinders have become worn 1/8 in. or more, they should be re-bored and fitted with packing rings turned to fit the re-bored cylinders, such rings being maintained in stock.

Hot-box reports should receive prompt attention. If a locomotive is equipped for the use of water on hot bearings developed en route, it should be known that there is no stoppage in the line of water travel to insure an available supply when the need arises. Water cooling equipment on locomotives should not in any way relieve the roundhouse from prompt attention to defects causing hot bearings.

A habit has prevailed to some extent which has been expensive wherever practiced. That is, allowing locomotives due for the shopping in two or three months to run with valves out of square, with clyinders blowing, leaky flues, or some defect which materially affects the successful operation of the locomotive. The money wasted due to not making repairs which would have permitted the economical and successful operation of the locomotive, would have been saved many times over while the engine was waiting to go to the shop.

All auxiliary devices, such as bell ringers, headlight dynamos, firedoors, steam grate shakers, power reverse gear, etc., should be kept in good repair. Many of them are put on the locomotive to increase the economy of locomotive operation and unless they are maintained, the effect is just the opposite.

No lost motion in power reverse gear levers and connections should be allowed and no air leaks in the piping should exist. If these two things are taken care of and the packing is well maintained, there should be little trouble from reverse gears creeping. Usually, the engineer is relieved from oiling the reverse gear and oftentimes this is neglected in the roundhouse, resulting in a dry piston, which means a slow acting gear.

Where flange oilers are used, the nozzle which feeds the oil to the flange should be in alinement with the flange and kept securely fastened there so that the oil will be deposited on the flange and not on the tread of the rail. A heavy, sticky oil should be used for flange oilers in preference to the lighter crude oils. This gives a longer wearing lubricant, materially assisting in the reduction of rail wear in addition to reduced flange wear.

Injectors should be maintained so that they will go to work without excessive attention on the part of the engine crew. One of the most annoying features with which enginemen have to contend is an injector which will not go to work unless fussed with for some time. This causes unnecessary safety valve operation and oftentimes an actual neglect of the fire, all contributing to a direct fuel waste.

Firedoors of the manually operated type should be evenly balanced, insuring ease of operation, equipped with a good latch on the door to hold it open when the track is rough or in going around curves. It is impossible to fire well if the door closes while the fire is being put in. The chain should be hung so that the firemen can reach it and open the door with a minimum of effort. In fact, he should be able to open the door and close it between each scoopful of coal fired, hardly knowing that the door is there.

Safety valves should be coordinated with the steam gage so that the blow-back should not be more than three or four pounds.

The apron between the deck of the locomotive and the

shovel sheet should be level. An apron which is curved or bent in any manner makes it difficult for the fireman to stand securely while firing. To enable the fireman to practice skillful firing, there should be no hindrance to a full, easy play of the muscles. Bent or curved aprons and roughed shovel sheets hamper the smooth work of a fireman materially. The shovel sheet should be level and free from any obstructions which will interfere with the movement of the shovel over the sheet and should extend back far enough into the coal to allow the fireman to get practically all of the coal out of the pit. A coal guard should be placed in the right gangway to prevent coal from being pushed out.

Brick arches should be maintained as shown by standard instructions.

Steam leaks around the locomotive are not only a Federal defect but are wasteful of steam.

The air brake system on the locomotive should be maintained free from leaks, and the compressor should be in as near 100 per cent condition as possible. The loss in time necessary to charge trains with the accompanying loss in fuel through steam consumed when the compressor is in poor condition is illustrated by the accompanying table from Mr. Willsie's paper, mentioned previously:

"The actual number of cubic feet of free air compressed to 100 lb. per minute pressure with 200 lb. steam by several compressors is as follows:

Compressor	100 per cent condition	75 per cent condition
9½-in.	44 cu. ft.	33 cu. ft.
11 -in.	66.5 cu. ft.	50 cu. ft.
8½-in. C. C.	131 cu. ft.	97.5 cu. ft.

"The 100 per cent condition referred to is the capacity of the air end of the compressor when in perfect condition, and is necessarily considerably less than the actual displacement of the compressor air piston.

"The 75 per cent condition referred to is the minimum condition permissible under the Interstate Commerce Commission ruling, and relates to the 100 per cent condition first mentioned."

It is necessary to use a drifting throttle on superheated locomotives to insure good lubrication. If a drifting throttle is to be used, we should provide the engineer with a throttle that will stay set in any position desired. Many throttles of necessity are shut off entirely or are nearly wide open and the engineer has to use a stick or try and hold the throttle in a drifting position, which is practically out of the question.

Engineers must be encouraged to make out the necessary reports for the guidance of the roundhouse foremen in maintaining the locomotive. A locomotive inspector, preferably an engineer, who would meet incoming engines while the crews are still on them, talk with the crew about the locomotive performance, help them make necessary tests to determine blows, etc., assist the engineer in making out his report, possibly making out a separate one, and then check the work done on the locomotive when it comes out of the roundhouse, can be of untold value to any mechanical organization, as these men not only uncover many defects but help educate the engineer to make out intelligent work reports, saving the mechanics considerable time in hunting for defects.

Terminal Handling

After the actual mechanical work of preparing the engine for service has been finished, we are going to assume that the transportation officer is cooperating with the mechanical officer, making it feasible to place a definite order for the locomotive for a certain time. Definite printed instructions should be posted in every roundhouse showing just how far in advance of leaving time, each class of power should be fired up and just how the fire should be built. The fire builders should follow this line-up.

To prevent pops opening in firing up, the blower should be shut off before the maximum steam pressure has been reached. This, of course, implies that the instructions to the fire builder provide against any heavy firing which would have built up too heavy a fire before leaving time.

When air brake men come around to test the air pump and brakes, they should not put more coal in the firebox and run the pressure up to the maximum, going away and leaving the pops blowing indefinitely.

Too many times when the fire is built an excessive amount of water is put into the boiler. When the engine is taken out of the house and placed on the storage track so full of water that it is impossible to work the injector any more, there is bound to be an excessive operation of the safety valves. When the engine crew arrive and the boiler is full, it is impossible for the fireman to build up the right kind of fire without the loss of a great deal of fuel through the safety valves. The boiler should be filled with sufficient water to prevent any danger of low water before steam pressure enough is obtained to work the injectors. The fire should be built up gradually, using just enough fuel to raise the temperature high enough to make all necessary tests before the engine goes into service.

From 20 to 30 per cent of the total fuel consumed by the locomotive is used around terminals, and there is room for real economy in the building of fires, if it is systematically supervised.

After the fire is built and the engine taken out of the house, just enough fire should be maintained to keep water enough in the boiler to provide against low water. With the boiler supplied in this manner, it is possible for the fireman to build up a fire of the right depth without excessive popping.

Hostlers should be taught by demonstration the way the fire should look when the engine is taken out of the roundhouse and inspection should be made of every fire before taking the engine out of the house. When poor fires are being built a report should be made to the roundhouse fireman to prevent a continuance of such practice. Lack of attention to fire building, resulting in poor fires being turned out of the roundhouse, has been responsible for many delays due to cleaning fires between terminals.

Cylinder cocks should always be opened and the engine started slowly when being taken out of the house or moved around the terminal by the engine watchman or hostlers. The cylinders nearly always contain water, and unless the cylinder cocks are open and the engine moved slowly, this water is worked directly through the cylinder and out through the stack. The writer is of the opinion that a great many of our cylinder leaks are caused by working water through the cylinders around terminals.

When engines are placed on the outgoing track, all tools and oil cans should be on the engine in good condition so that the crew will not have to run around looking for supplies, which takes time away from their regular duty of preparing the locomotive. Incoming locomotives should be dispatched with the greatest possible speed to insure all of the time possible in the roundhouse for necessary work. If the roundhouse is too small to handle the business, it is better to take out the engine which has been repaired and make room for an incoming engine needing repairs than to keep the incoming engine outside for several hours and then, when it is in the house, have to turn it out again without having time to do the necessary work.

Many different local conditions handicap thorough mechanical repairs. I remember an instance last winter on a certain railroad where we found the superintendent and master mechanic cleaning fires on the cinder pit to assist in moving power through the terminal. It is obvious that many things which have been suggested in this paper will be lost sight of under such conditions, but we must have high ideals or our general practice will be of a low standard.

New Devices

A 14-INCH GEARED HEAD LATHE WITH COMPACT MOTOR DRIVE

A new 14-in. geared head lathe with a compact arrangement for motor drive has been placed on the market by the Reed-Prentice Company, Worcester, Mass. It is a well balanced machine and the distribution of metal is apportioned to absorb vibration under heavy cutting feeds and speeds. In casting the various units an equal thickness of walls was maintained so that when cooling undue internal strains would not develop, and distort the machine after delivery.

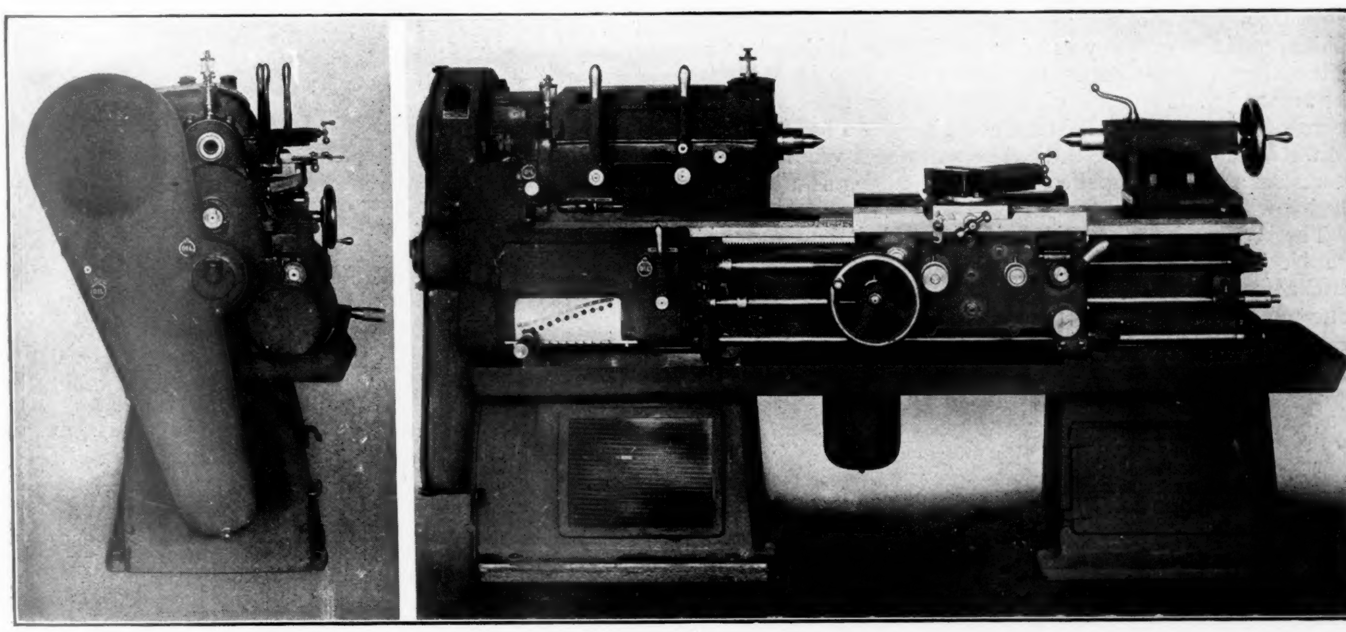
The lathe headstock is of the selective type, permitting the operator to obtain any one of eight speeds without slowing down the machine or removing the cutting tool from the work. It is stated that the change from one speed to another cannot be detected on the work even should such a change be made while the tool is taking a cut. The speeds are obtained by the use of spur gears which are constantly in mesh the full width of face and depth of tooth. The internal expanding friction clutches are of special patented design. It is impossible to engage conflicting ratios of gears as the spindle will not start until the three levers are in operative position. Therefore, any one of the levers when brought to a neutral position will at once stop the spindle. The spindle bearings are hardened and ground. The journal boxes are of bronze, scraped to the spindle to insure correct alinement and maximum bearing surface.

The back gears, spindle and pulley shaft have been brought up to the same plane which makes them much more accessible and permits the gears to run in an oil bath. The intermediate bevel gear in the reversing attachment being brought up to a plane with the pulley shaft, permits more rigid construction of the shipper mechanism and a more accessible arrangement for adjusting the friction fingers when necessary.

In order to remove the face plate from the spindle nose, a locking mechanism has been introduced in the form of a plunger which engages the hardened steel notched ring, keyed directly to the spindle. This prevents the rotation of the spindle and permits the removal of the face plate without transmitting any strain to the gear teeth. To insure against starting the spindle while this plunger mechanism is in operation, a locking mechanism has been introduced which prevents the engagement of the spindle clutch until the plunger has been removed. In case the clutch is engaged, the locking mechanism also keeps the plunger set at neutral position.

A geared pump in the headstock supplies the lubricating oil for all of its bearings, with the exception of the two main spindle bearings, which are supplied from sight feed oilers as shown. Ball bearings of the Gurney type are used in the drive pulley, which eliminates most of the friction due to belt tension. The rocker carrying the tumbler gears at the end of the head is of new design, being a pull plunger with locating holes in the side of the head. The spindle is reversed by means of bevel gears and shafts in preference to the old link motion. The control handle for the stop, start and reverse is located at the right hand lower corner of the apron and is therefore at all times in a convenient position for the operator. The quick change gear of this lathe has also been modified to make the entire unit more accessible and rigid.

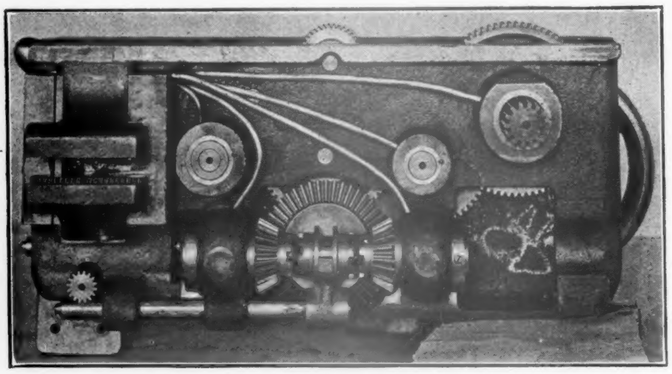
The carriage apron is of double plate construction, which permits easy access to the internal mechanism without removing the carriage from the bed. The shafts and studs are sup-



Reed-Prentice 14 In. Geared Head Lathe with Driving Motor Located Inside the Cabinet Leg

ported at both ends in bronze bearings. The rear plate is made in box form securely bolted to the carriage. The open-and-shut nut works in guides which are cast integral with the rear plate. A new locking mechanism, simple and rigid in construction has been incorporated to prevent the engagement of the longitudinal feed when the open-and-shut nut is engaged and vice-versa. An oil reservoir with protecting dust cap is placed at the upper right hand corner of the apron for lubricating all of the bearings in the rear plate. The front bearings are lubricated by oilers provided at each bearing.

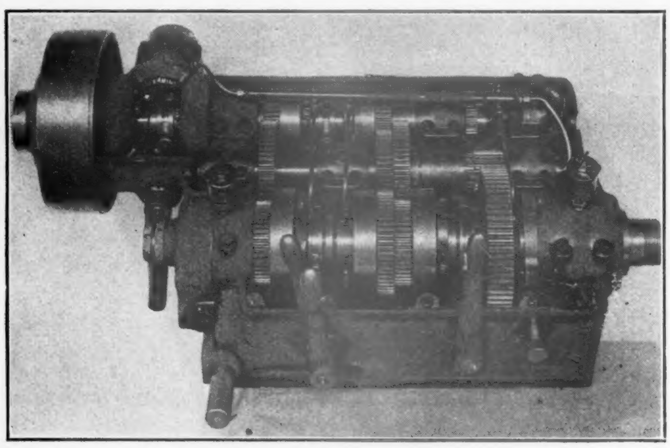
The carriage has an exceptionally large area over the



Rear View of Apron Showing Double Plate Construction and Feed Bevel Gear Arrangement

sliding surfaces on the vees of the bed. The bridge does not extend by the front horns, this being overcome by widening the apron seat. The tailstock has been strengthened and made more rigid by widening the base and giving it a better support on the inside vees of the bed. The additional vee in the tailstock has a reinforcing effect on the bed, acting as a clamping device wherever the tailstock is located.

The bed has been not only widened and deepened considerably, but reinforced throughout by increasing the metal thickness and spacing the heavy ties much closer together. The top of the bed is of the drop vee type, the inside vees



Back Gears, Pulley Shaft and Spindle are all in the Same Plane

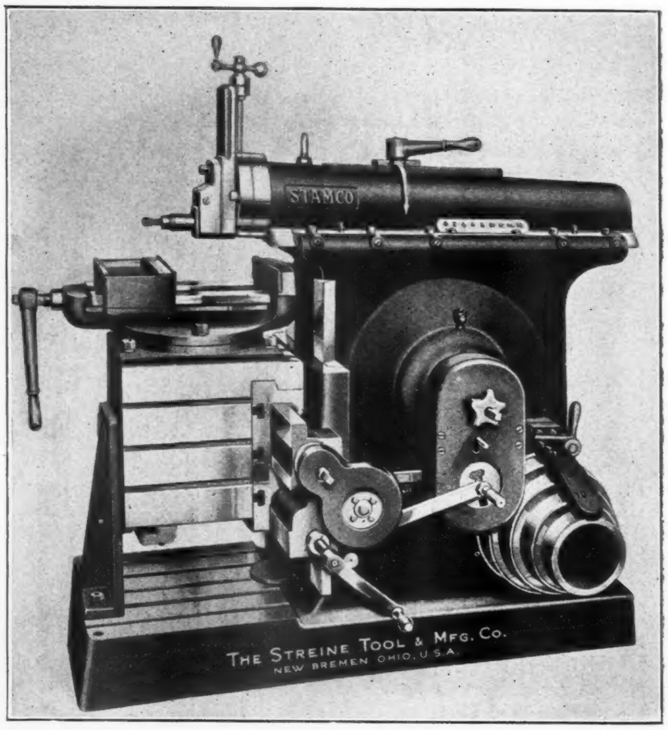
being lower than the outside, thereby preventing any excessive cut in the bridge of the carriage.

Slight improvements have been added to the taper attachment, particularly in the method of guiding the traveling shoe on the taper bar. There has always been a tendency of the shoe to lift from the bar when under pressure, which had a slight effect on the work. This has been eliminated by the introduction of a gib engaging a ledge planed the entire length of the taper bar. Graduated dials, reading in the thousandths of an inch, are made a part of the rest screw. When the lathe is belt driven directly from the main line or countershaft, standard cabinet legs are used, having doors in the front so that the space inside may be utilized for storage purposes. The steel oil pan with oil reservoir pump and piping are furnished when ordered.

Two types of motor drive can be furnished. In the one illustrated the motor is mounted inside the head-end cabinet leg and connected to the head drive shaft by a carefully guarded belt or silent chain. This arrangement is compact, protects the motor and eliminates the overhang of motor or pulleys. The second method of motor drive is through rawhide spur gears with the motor mounted on a bracket at the rear of the machine. The bracket is bolted to a pad cast integral with the head end cabinet leg.

HEAVY DUTY CRANK SHAPER

A 16-in. heavy duty back geared crank shaper has been developed recently by the Streine Tool & Manufacturing Company, New Bremen, Ohio. The base of this shaper is of the extended type, unusually deep and affords a solid foundation for the machine. T-slots in the large planed



Stamco 16-in. Heavy Duty Shaper of the Extended Type

surface run back to the column, as shown in the illustration, and provide for setting up large pieces of work. The rigid construction of the machine throughout renders it suitable for the heavy work usually found in railway machine shops.

The column is of unusual depth and width at the base, thus making a more rigid joint between the base and the column, and at the same time lowering the center of gravity. The bull gear bearing is cast solid in the frame, which eliminates considerable wear caused by springing and friction. The bull gear itself is supported close to the rim by the frame which does away with the tendency for it to bind or break away from the hub. The total area of the bull gear bearing is 205 sq. in.

The crank block and its adjusting mechanism are set into the bull gear, thus reducing the overhang between the rocker arm and the gear to a minimum. The bull gear construction and its relation to the rocker arm, as mentioned above, eliminates practically all vibration and chatter, without making the working parts too heavy and cumbersome.

The bull pinion rotates on bronze bushings as in the

usual planer construction, and the intermediate gears are mounted on extended hubs of the pinion. The driving gears are mounted on a long sleeve, which slides on a key in the pulley shaft. The gear ratio is arranged so that the speeds of the ram are in geometric progression and there are no conflicting gear ratios as in some forms of pinion gear drive. The pulley rotates in a sleeve bearing bolted to the column, thus relieving the shaft of belt pull and eliminating an extra bearing. An unusually long ram bearing is provided, which insures accuracy and reduces wear to a minimum. The rail is clamped to a dove-tail slide on the column, insuring accuracy in any position. The saddle fits into a narrow guide on the rail, which provides large wearing surfaces and equalizes the strain on the rail screw. The position of the table is controlled by means of a telescopic elevating screw, which is provided with a ball thrust bearing. The table can be removed, as previously stated, and large work bolted to the saddle or base.

Arrangement is made to vary or reverse the feed while the machine is in motion, and the feed can be set at any desired amount quickly. Owing to the absence of adjustable or friction links the feed is constant at any position of the rail. The adjusting screws are provided with micromoter collars, graduated to .001 in. and all adjustments are within easy reach of the operator. The head and the vise are graduated in degrees and can be set to any angle.

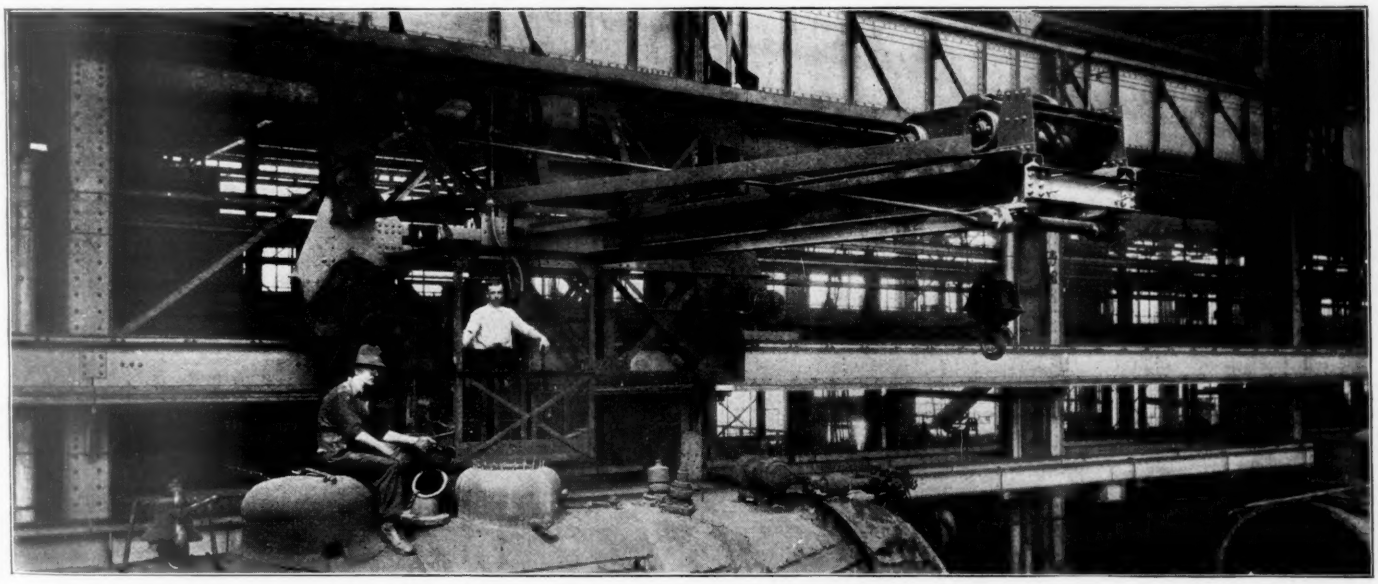
The shaper has an effective stroke of 17 in. with a cross feed of the table of 24 in. The vertical table feed is 15 in. and the greatest distance of the table to the ram is 16 in. The feed of the tool is 7 in. and the diameter of the head 8 in. The number of strokes per minute may be adjusted from 6 to 120.

TRAVELING WALL CRANE

The traveling wall type of crane has proved its value in the satisfactory solution of handling problems in many plants. Used as an auxiliary to the overhead cranes, it avoids delays and congestion and leaves the overhead cranes free for heavier loads and longer runs. The crane shown is designed and built by the Toledo Bridge & Crane Company, Toledo, Ohio. The four-motor type drive is used and arrangements can be made for either direct or alternating current motors. The crane is regularly furnished in capacities of three and five tons and for an effective reach up to 30 ft.

The back framing and the boom consist of rolled steel channels, beams, plates and angles, combined in a rigid structure. Truss rods or eye-bars give stability to the boom. Two motors connected in parallel and operated through one controller are provided for the longitudinal travel. The motor pinion engages directly into the driving gear which is pressed and keyed onto the double-flanged cast-steel truck wheel. The thrust wheels at the top and bottom are turned from solid cast steel blanks. A foot brake operated from the cage is provided to effectually control the longitudinal travel and to stop the crane without the necessity of reversing the motors. The brake is of the band type, the brake wheel being mounted directly on the armature shaft of one of the motors. The operator's cage, made of structural steel with a plank floor, is of sufficient size to contain all controllers, the switchboard and resistance, and still leave ample room for the operator. When desired the cage can be omitted, rope-operated controllers provided and all operations can then be accomplished from the floor. With the floor-operated type the foot brake is omitted and a solenoid brake provided, the latter being attached directly to one of the driving motors. A bumper bar and rail checks are provided at the end of the boom.

The hoisting mechanism consists of a one-piece cast frame on which is mounted the hoisting motor with its train of gears, the solenoid brake and hoisting drum. The gears are of cast steel. All pinions are of forged steel, machine cut and fully enclosed. The bearings are phosphor bronze, of the split shell type, the grey iron bearing caps being held in position with through bolts. The shafts are turned and ground to size from open hearth steel bars and shouldered to prevent excessive end play. Gears and pinions are keyed and pressed onto their shafts. The hoisting cable leads from the drum through one set of idler sheaves on the trolley, through the bottom block sheaves, then through the second set of sheaves on the trolley and is anchored at the end of the boom. The solenoid brake performs two functions. It serves to stop the motor, thus providing for rapid reversal, and it also acts as a holding brake when the load is brought to rest through the dynamic braking control. The brake wheel is mounted directly on the extended armature shaft, and is accurately machined and balanced. The brake is automatic in operation, and is so arranged and connected that should the supply of current fail or the controller be brought to the neutral or off position, the brake at once becomes operative, prevents the load from falling or slipping and is released only by the application of power or by spread-



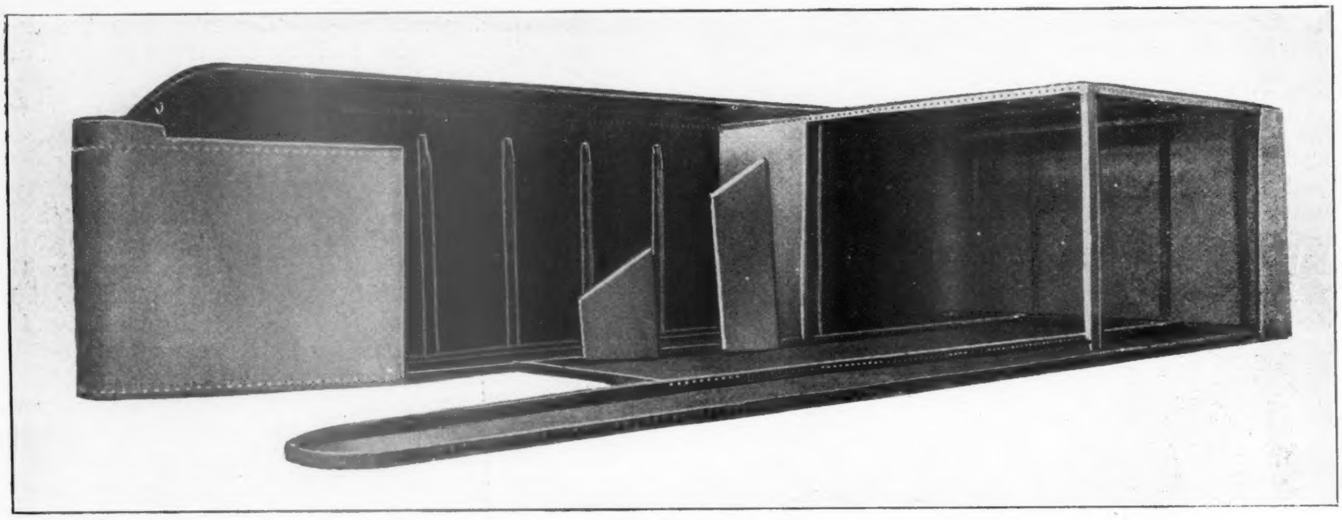
Traveling Wall Type Crane in a Longitudinal Shop

ing the brake arms against the tension of the springs. When alternating current motors are used the hoist motor is provided with a solenoid brake and the standard band type of mechanical brake is applied. This brake is of the screw friction type, automatic in operation, and the load can be lowered only by operating with power in the lowering direction.

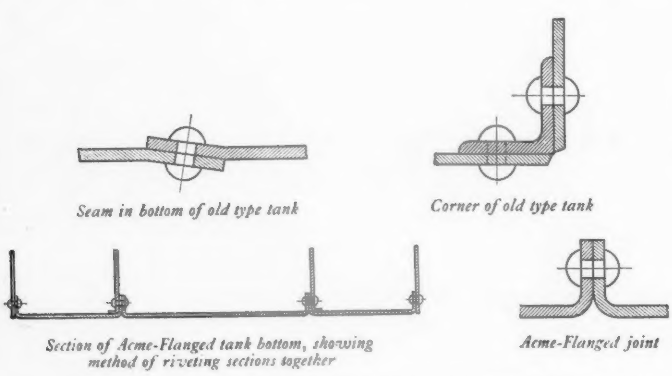
THE ACME FLANGED LOCOMOTIVE TENDER TANK

A locomotive tender tank formed of flanged steel plates is being placed in service on a number of large railroads by the Locomotive Tank Company, New York.

The special feature of this tender tank, which is known as the Acme flanged tank, is the flanging of the edges of the plates inwardly and riveting them together inside of the water space instead of on the under side of the tank, where the rivets are difficult of access in case of leakage requiring repairs. Repairs can be made to the bottom of this tank without raising it from the frame, as all of the riveting is done on the inside. This feature not only reduces the cost of repairs, but as the flanged portion of the plates provides a means of riveting them together, a great number of the angle irons and rivets required in the older types of tender tanks are eliminated.



Acme Flanged Locomotive Tender Tank Showing the Accessibility of the Riveted Joints



Comparison of Acme Flanged Joints with the Old Type Joints

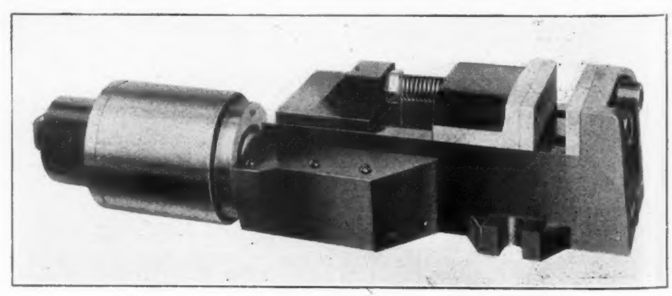
Other advantages of this type of construction are that no rivets or holes pass through the top or bottom of the plates and the bottom of the tank sets firmly and smoothly on the tender floor, thus evenly distributing the strains. The absence of angle and T-irons and sharp corners in the interior of the tank also prolongs the life of the bottom. The center section or pan is directly under the water intake and tends to retain in it such pieces of coal, cinders and sediment as might pass through the screen and if carried on with the water would interfere with the operation of the injectors.

It is stated that the tests to which this tender tank has been subjected and the record of costs for material and manufacture indicate that it will prove to be a very economical method of locomotive tender construction.

PNEUMATIC MILLING MACHINE VISE

A milling machine vise, so designed that it can be operated by air or used as an ordinary hand-operated vise, has been placed on the market recently by the American Pneumatic Chuck Company, Chicago. This vise is made so that it may be placed either crosswise or lengthwise on the table of the machine. No part extends above the jaws which hold the work, so the cutters can pass over the entire vise. The design follows the modern standard milling machine vise in the construction of jaws, screw slide and tongues and slots. The body is made of a steel casting and the entire construction is substantial and rigid. The adjusting screw slide is built into the body of the vise, becoming practically a part of it. It is claimed that this vise is economical in the use of air due to the fact that after the piece of work has been gripped by the jaws, the air supply may be shut off entirely without the jaws loosening up.

The power required to hold a piece of work in any vise is greater than usually realized, and this milling machine vise is fitted with a 4-in. air cylinder, which with 80 lb. pressure on the piston gives a total pressure of about 1,000 lb. By means of a toggle joint arrangement on which patents are pending, this initial pressure is increased by more than 30 to 1, which, making allowances for friction, etc., gives a final gripping power at the extreme point of movement of the



Air or Hand Operated Milling Machine Vise

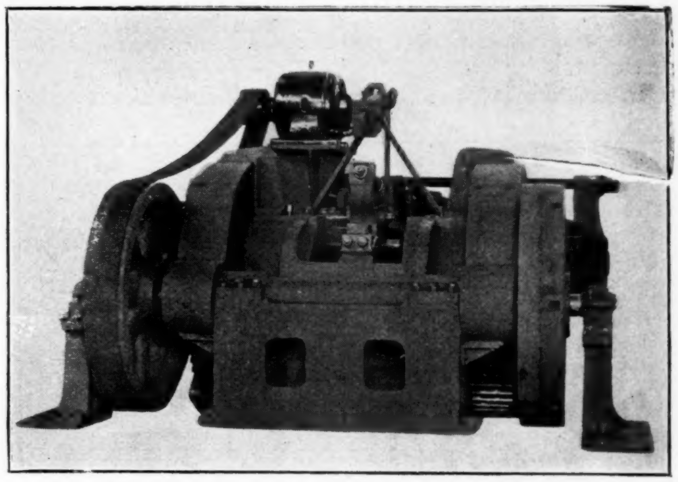
piston of about 25,000 lb. pressure on the work. While the vise is capable of exerting this heavy pressure, it is claimed that the jaws can be adjusted so that the most delicate work can be held without crushing it. The double acting air cylinder opens and closes the jaws practically instantaneously, but they can be so regulated as to travel slowly towards the work. The air valve is mounted directly on the cylinder and requires only one hose connection.

HEAVY UPSETTING FORGING MACHINE

The steady increase in the use of alloy and high carbon steels in forging has created a demand for heavy forging machines to stand up under the increased strain of working these materials. Accurate, economical, high production is also desirable and the upsetting forging machine illustrated has been designed by the Ajax Manufacturing Company, Cleveland, Ohio, to include all of the above qualities. The machine weighs 12,000 lb., which is about 40 per cent heavier than the old 4-in. model. The steel bed is reinforced with tie rods. The crank shaft bearings in the continuous housing of the bed are of the sleeve type, phosphor bronze bushed, and the steel gears and pinions are especially treated with teeth cut from solid blanks. The positive die grip is protected by a breaker bolt in the safety knuckle, the latter being operated by a patented lock device which stops the dies in the wide open position and stops the header slide at the back of its stroke.

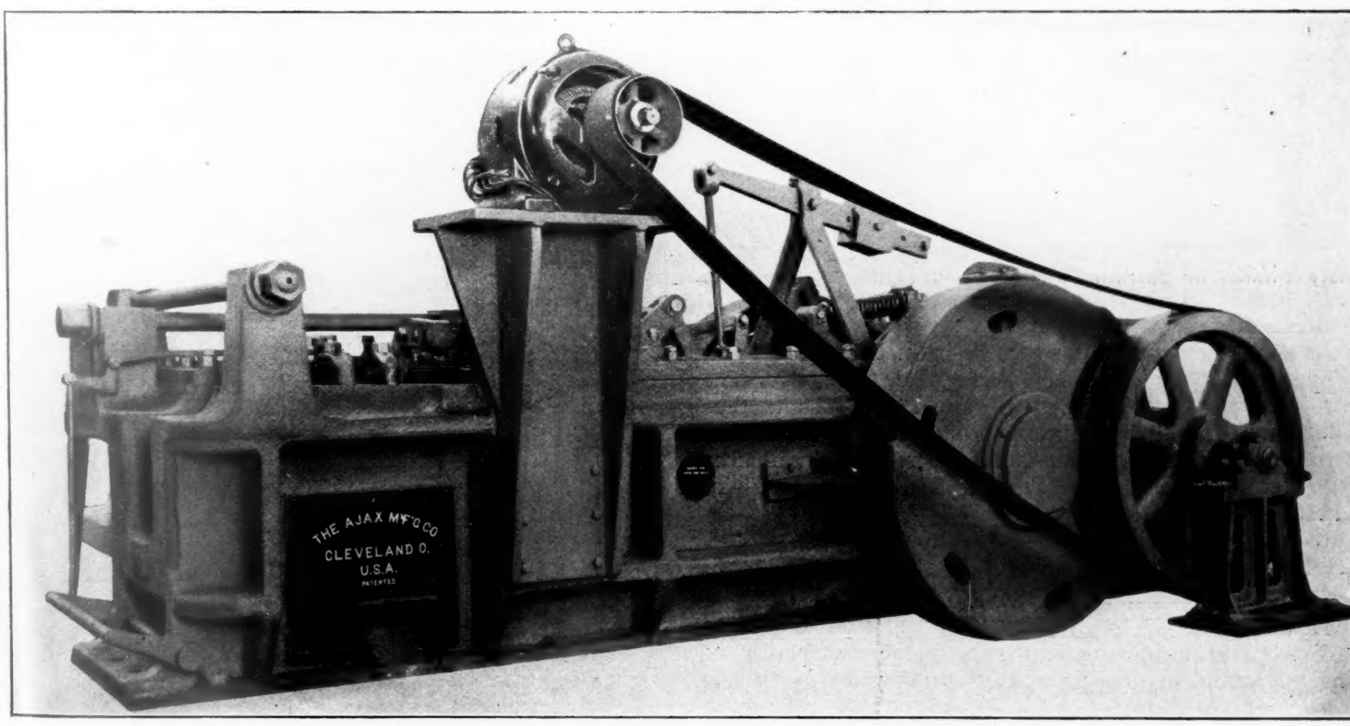
The capacity of the new forging machine has been demonstrated in tests recently conducted at the Cleveland plant. It is stated that a 4-in. machine, in a single blow, forged a disk 9½ in. in diameter and 1¼ in. thick on the end of a 3½-in. bar of steel of .60 carbon content at a cherry red heat. In doing this eight inches of stock were gathered and flattened out without stalling the machine.

The slides are considerably increased in length and operate on overhung bronze faced bearings, thus preventing undue wear by the accumulation of scale and dirt on the sliding surfaces. Arrangement is made for ample lubrication. The header slide carries a triple-high tool holder, so constructed as to permit its adjustment to any desired location of the grooves in the gripping dies. The die slide carries the moving die in a box shaped recess which gives substantial support against the backing plate during the heading operation. Local wear in the backing plate and the resulting tendency of the die slide to rock is thus eliminated. In order to transmit the power necessary for the making of large forgings, a twin gear drive from the pinion shaft to the crank shaft is employed on all machines of the larger sizes. This gives equal torque to both ends of the crank pin, greatly decreasing the strain in this part. In addition, the crankshafts have been nearly doubled in weight.



Rear View, Showing Twin Gear Drive

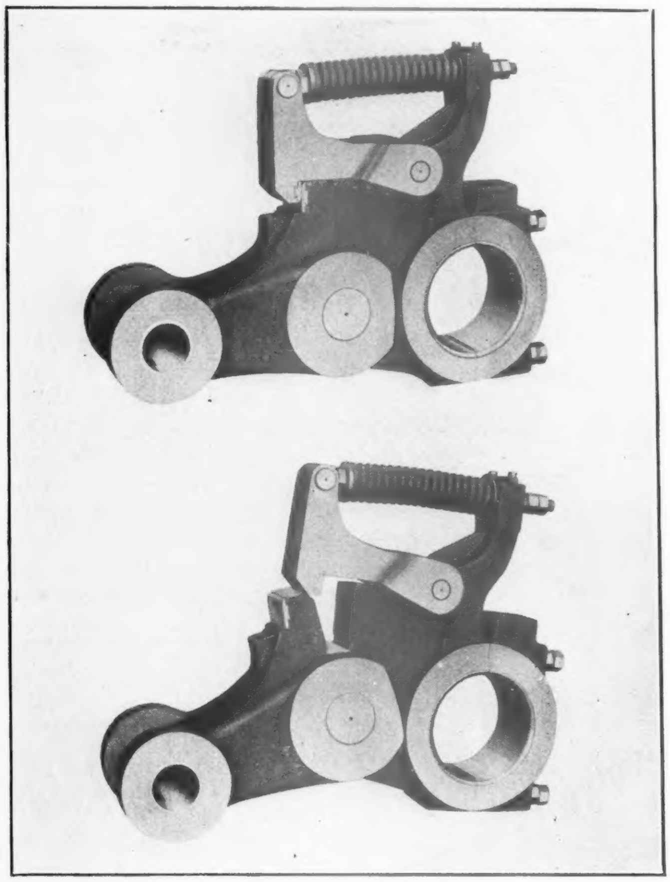
The self-adjusting safety pitman, the construction of which is shown in the photograph, is a new feature. The middle center is slightly raised above the line of the other two so that a pressure on the ends results in a buckling tendency. This buckling is resisted up to a predetermined pressure by the latch held in place by the heavy coil spring. When the limiting pressure is reached the latch jumps up, giving complete relief without the building up of additional pressure. On the return stroke the pitman straightens out, the



New Model Forging Machine Designed for High Production

latch drops into place and the machine is ready to go on with its work with no delay. By tightening or loosening the spring a nicety of adjustment can be obtained which permits the working of the machine to its full capacity with assurance that the limit of its strength will not be exceeded. Machines equipped with this type of pitman have been in operation continuously for the past three years and have been giving a satisfactory performance under the most severe service tests.

In order to increase the capacity of the machine to corre-



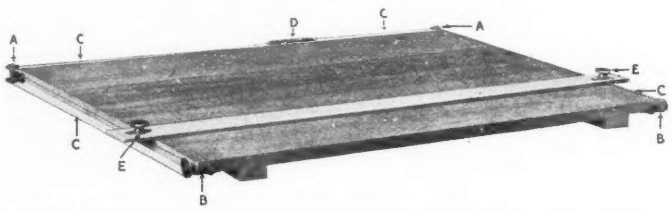
Safety Pitman in Operating Position and Sprung by Excessive Pressure

spond to its increased power and strength, the stock gather, die opening and die height have been greatly increased. The production of larger forgings in fewer operations is thus made possible and the additional space for the placing of more grooves in a single face of the die reduces the number of die changes necesssary. The machine is made in 4-in. and 5-in. sizes.

PARALLEL RULER ATTACHMENT

Several advantages result from the use of a parallel ruler attachment with a drawing board, one of the most important being the saving in time previously spent by the draftsman in watching the head of his T-square. The attachment shown herewith is more accurate than the average T-square and in addition can be adjusted at any required angle across the drawing board by means of the thumb nuts on the binding post.

This parallel ruler has been placed on the market by the Economy Drawing Table Company, Adrian, Mich. It consists of a set of two double pulleys *A* attached to the back corners of the drawing board, and two single pulleys *B*, attached to the front corners. A steel piano wire *C* is placed around these pulleys, making a double lap along each end and back of the board. By crossing the wire at the back the upper laps at both ends must move forward and back simultaneously. The ends of the wire are joined together at the back by a steel spring *D*. Both ends of the straight edge are attached to the upper wire at the ends of the board by binding posts *E*, thus making it possible to move one end of the straight edge without moving the other a corresponding amount in the same direction. All pulleys, brackets and



Economy Parallel Ruler Attachment Applied to Drawing Board

binding posts are made of brass accurately machined, polished and lacquered. The attachment is accurate, as both ends of the straight edge are attached to the same wire and can be moved back and forward only simultaneously. The straight edge can be lifted clear of the board for changing drawings without loosening any thumb nuts, and can be set at any angle across the board by thumb nuts on the binding posts. The entire arrangement is simple, durable and easily applied.

BOYERGRIP FOR PNEUMATIC HAMMERS

The Boyergrip is a device recently brought out by the Chicago Pneumatic Tool Company, Chicago, which combines a convenient hammer grip with an absolutely safe set retainer. As shown in the illustration, it fits over the end of the riveting hammer and enables the operator to secure a firm grip without grasping the heated cylinder. This arrangement makes the operation of the hammer more convenient and allows the workman to drive hot rivets without

Combined Hammer Grip and Set Retainer

danger of burning his hands. The device also provides an unobstructed view of the work from all angles. The Boyergrip is made of steel and is practically indestructible. A modified form of this device, which is well adapted for use on chipping and calking tools has also been placed on the market.

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WE GUARANTEE, that of this issue 12,000 copies were printed; that of these 12,000 copies, 10,803 were mailed to regular paid subscribers; 20 were provided for counter and news company sales; 219 were mailed to advertisers; 33 were mailed to employees and correspondents, and 925 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 24,200, an average of 12,100 copies a month.

THE RAILWAY MECHANICAL ENGINEER is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. P. C.).

In an effort to encourage more skilled workmanship the Canadian Pacific inaugurated a competition among apprentices at the Angus shops, and the five winning pupils were recently presented with prizes of books by James D. Muir, assistant works manager, at a gathering presided over by C. Kyle, supervisor of apprentices. There were present about 423 apprentices and Mr. Muir pointed out to them that it was only by diligent work that advancement to a marked degree was attained, and that full interest in their tasks was a necessity. Others who spoke were J. R. Ayers, general master painter; E. T. Spidy, production engineer; John Kennedy, piece work supervisor; Charles Bulley, class instructor of the apprentices, and J. W. Wood, shop instructor.

The rumor reported in the January issue that the Ministry of China has engaged four foreign experts to assist in the standardization of rolling stock is now abundantly confirmed by the arrival of these gentlemen in Peking. One is Frank H. Clark, formerly superintendent of motive power of the Baltimore & Ohio. The others are T. R. Johnson, formerly commissioner of railways, New South Wales, and latterly engaged in consulting work in London; M. Taton, personal representative of M. Painlevé, formerly Minister of War, France, who was engaged by the Ministry, but is unable to come at present, due to political conditions in France, and Dr. Hirai, the present Japanese Adviser to the Ministry. In addition to the standardization of rolling stock, this group will attempt to standardize signal practice, bridge dimensions and other maintenance practice.

In an article on the transport and coal question in the Börsen Courier, quoted in the Railway Gazette (London) a leading German manufacturer of locomotives says: "It might appear that the German locomotive industry is specially interested in receiving orders from the State Administration. The opposite is really the case. In the large locomotive works in Germany new locomotives are being built, mainly out of pre-war material, and production in the workshops has increased that it may be said to have reached the peacetime standard. The Hanoverian Maschinfabrik, for instance, is at the present time building some 32 new locomotives monthly, with the employment of 5,000 permanent workers. Having regard to the present economic situation in Germany, the only strange fact about this is that these locomotives are all sold to foreign countries. The prices which foreign countries are offering for German locomotives are such as to enable the manufacturers to provide themselves with all kinds of material, not only machinery, oil, etc., but also coal either from Germany or abroad."

The Brotherhood of Maintenance of Way Employees and Railway Shop Laborers has bought four clothing factories, and promises to reduce prices from 25 to 60 per cent. The factories include knitting and underwear companies at Ypsilanti, Mich., a glove factory at Williamston, Mich., and a tubing factory, making tubes used in gloves, in Watertown, N. Y. Unverified reports of such action have been in circulation since the authorization of such a campaign at the national convention of the brotherhood in Detroit, Mich., in September, 1919. The present report has been confirmed by officers of the brotherhood, who announce that the purchases thus far consummated represent an initial investment of approximately $1,000,000 and are "but the first steps" in a campaign to reduce the cost of living for members of the brotherhood. It is proposed to sell to the members of all railway brotherhoods.

North British Railway Changes

W. P. Reid, locomotive superintendent of the North British Railway, retired from active service at the end of December. Mr. Reid started his railway career in 1876 under the direction of Dugald Drummond, then locomotive superintendent of the North British railway, at the Cowlairs works. In 1883 he was placed in charge of the locomotive depot at Balloch, in 1889 he was removed to Dumfermline, in 1891 to Dundee, and in 1900 to St. Margaret's depot, Edinburgh, which is the second largest locomotive depot on the North British railway system. It was in 1904 that he was made locomotive superintendent of the North British railway.

Owing to the retirement of W. P. Reid, the position of locomotive superintendent will be divided, and Walter Chalmers, the present chief draftsman at the Cowlairs works, Glasgow, will become chief mechanical engineer with charge of all workshops and dock machinery, while the position of locomotive running superintendent will be taken by John P.

Grassick, at present district locomotive superintendent at the Eastfield depot. The headquarters will be at Cowlairs, Glasgow.

Mexico to Spend $2,000,000 for Equipment

An appropriation of 4,000,000 pesos, equivalent to $2,000,000, has just been authorized by the Mexican government for the purchase of rolling stock for the National Railways of Mexico. Most of the new equipment will be second-hand and will be purchased in the United States. There is at present such a shortage of cars and engines upon the different divisions of the National Railways that it is impossible to move but a small percentage of the traffic that is offered. Thousands of box cars have been wrecked by bandits and revolutionists during the last several years. The shops of the railroad at Saltillo, Aguas Calientes and other points are doing considerable work in the matter of reconstructing damaged cars and engines, but the number which is being turned out is far from sufficient to meet the demands of traffic. Thousands of new railroad crossties are needed to repair the rundown condition of the system. Large orders for materials have been placed in the United States and some shipments of crossties have been received. In the more isolated parts of the country where timber is scarce the sidetracks have been torn up by poverty-stricken natives and the crossties used for fuel.

Standard Cars and Locomotives

Up to January 20, 92,412 of the 100,000 standard freight cars ordered by the Railroad Administration in 1918 had been delivered, leaving 7,588 to be completed. Of the total, 12,680 were built in 1918 and 77,423 in 1919. All of the standard locomotives will have been delivered by the end of January, but 11 Mikados of a special order placed for the Central Railroad of New Jersey are scheduled to be delivered in March.

Most of the locomotives which the Railroad Administration has been using during the period of federal control on roads other than those of their owners have now been "unscrambled" by being returned to their owners. According to a recent report there were still 515 locomotives off their own lines, of which 95 were in the Allegheny region, 66 in the Central Western region, 135 in the Eastern region, 49 in the North Western region, 15 in the Pocahontas region, 104 in the Southern region and 51 in the Southwestern region, but 236 included those whose location off line is a system affair over which the Railroad Administration need not concern itself. The location of 155 was required by public necessity and apparently they will still be so required to be off line on March 1. The location of 95 off line was at that time required by public necessity but there was some prospect of relocating it before March 1 either through termination of the necessity, by a rearrangement of equipment, or by repair of unserviceable equipment in shop. Only 29 locomotives were classified as being off the line for reasons not required by public necessity.

MEETINGS AND CONVENTIONS

Air Brake Association.—The twenty-seventh annual convention of the Air Brake Association will be held at the Hotel Sherman, Chicago, from May 4 to 7, inclusive. The Air Brake Appliance Association will have charge of the exhibits.

Material Handling Machinery Manufacturers' Association.—The convention of this association which was to be held at the Waldorf-Astoria Hotel, New York, on January 29 and 30, has been postponed, and will be held on February 26 and 27. Manufacturers from any part of the United States will be welcome, and especially makers of overhead cranes, hoists, conveyors, trucks, tractors and trailers. Reservations for the luncheon may be procured from Z. W. Carter, secretary, 35 West 39th street, New York.

American Foundrymen's Association.—The board of directors of the American Foundrymen's Association, at its annual meeting held in Cleveland on January 13, voted unanimously in favor of holding the 1920 convention and exhibit of the association in Columbus, Ohio, during the week of October 4. The exhibition buildings on the Ohio State Exposition Grounds will be used for the exhibits. In addition, adjoining buildings provide lecture halls and meeting rooms, making it possible to hold all the activities of the association in one place.

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations:

Air-Brake Association.—F. M. Nellis, Room 3014, 163 Broadway, New York City. Convention May 4-7, Hotel Sherman, Chicago.

American Railroad Association, Section III.—Mechanical.—V. R. Hawthorne, 431 South Dearborn St., Chicago.

American Railroad Master Tinners', Coppersmiths' and Pipefitters' Association.—O. E. Schlink, 485 W. Fifth St., Peru, Ind.

American Railway Tool Foremen's Association.—R. D. Fletcher, Belt Railway, Chicago.

American Society for Testing Materials.—C. L. Warwick, University of Pennsylvania, Philadelphia, Pa. Annual meeting, June 21, 1920, New Monterey Hotel, Asbury Park, N. J.

American Society of Mechanical Engineers.—Calvin W. Rice, 29 W. Thirty-ninth St., New York.

American Steel Theaters' Society.—Arthur G. Henry, Illinois Tool Works, Chicago.

Association of Railway Electrical Engineers.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago.

Car Foremen's Association of Chicago.—Aaron Kline, 841 Laylor Ave., Chicago. Meetings second Monday in month, except June, July and August, Hotel Morrison, Chicago.

Car Foremen's Association of St. Louis.—Thomas B. Koeneke, secretary, Federal Reserve Bank Building, St. Louis, Mo. Meetings first Tuesday in month at the American Hotel Annex, St. Louis.

Chief Interchange Car Inspectors' and Car Foremen's Association.—H. J. Smith, D. L. & W., Scranton, Pa.

International Railroad Master Blacksmiths' Association.—A. L. Woodworth, C. H. & D., Lima, Ohio.

International Railway Fuel Association.—J. G. Crawford, 542 W. Jackson Blvd., Chicago.

International Railway General Foremen's Association.—William Hall, 1061 W. Wabasha Ave., Winona, Minn.

Master Boilermakers' Association.—Harry D. Vought, 95 Liberty St., New York. Convention May 25-28, Curtis Hotel, Minneapolis, Minn.

Master Car and Locomotive Painters' Association of U. S. and Canada.—A. P. Dane, B. & M., Reading, Mass.

Niagara Frontier Car Men's Association.—George A. J. Hochgrebe, 623 Brisbane Bldg., Buffalo, N. Y. Meetings, third Wednesday in month, Statler Hotel, Buffalo, N. Y.

Railway Storekeepers' Association.—J. P. Murphy, Box C, Collinwood, Ohio.

Traveling Engineers' Association.—W. O. Thompson, N. Y. C. R. R., Cleveland, Ohio.

RAILROAD CLUB MEETINGS

Club	Next Meeting	Title of Paper	Author	Secretary	Address
Canadian	Feb. 10, 1920	The Manufacture of Tool Steel, illustrated with moving pictures	F. B. Lounsberry	W. A. Booth	131 Charron St., Montreal, Que.
Central				H. D. Vought	95 Liberty St., New York.
Cincinnati				H. Boutet	101 Carew Building, Cincinnati, O.
New England	Feb. 10, 1920	Handling of Purchases and Supplies	E. J. Roth	W. E. Cade, Jr.	683 Atlantic Ave., Boston, Mass.
New York	Feb. 20, 1920	What the Railroads Must Do to Make Good After March 1	J. H. Hustis and L. F. Loree	H. D. Vought	95 Liberty St., New York.
Pittsburgh	Feb. 27, 1920			J. D. Conway	515 Grandview Ave., Pittsburgh, Pa.
St. Louis	Feb. 13, 1920			B. W. Frauenthal	Union Station, St. Louis, Mo.
Western	Feb. 16, 1920	National Agreement	Frank McManamy	J. M. Byrne	916 West 78th St., Chicago.

PERSONAL MENTION

GENERAL

B. C. KING has been appointed assistant general boiler inspector on the Northern Pacific, with headquarters at St. Paul, Minn.

B. C. NICHOLSON, general foreman of the Denison locomotive shops of the Missouri, Kansas & Texas, has been appointed mechanical efficiency inspector, with headquarters at Parsons, Kansas.

F. K. TUTT, acting general master mechanic of the Missouri Pacific with headquarters at St. Louis, Mo., has been appointed mechanical superintendent of the Missouri, Kansas & Texas.

MASTER MECHANICS AND ROAD FOREMEN OF ENGINES

F. A. BISSET, general foreman of shops of the Atlantic Coast Line at Sanford, Fla., has been appointed master mechanic at Waycross, Ga., succeeding J. E. Brogden.

C. A. CONNER has been appointed traveling engineer and trainmaster of the Green River division of the Denver & Rio Grande, with office at Helper, Utah, succeeding C. H. Wilcken, who has resigned.

F. A. O'NEILL has been appointed road foreman of engines of the Erie, with headquarters at Cleveland, Ohio, succeeding J. E. Bleutge, resigned to accept a position as traveling engineer with the American Expeditionary Forces.

A. B. SHANKS, general foreman of the Missouri, Kansas & Texas of Texas at Smithville, Texas, has been appointed master mechanic with the same headquarters, with jurisdiction over the points south of Waco, Texas.

SHOP AN ENGINEHOUSE

J. E. BROGDEN, master mechanic of the Atlantic Coast Line at Waycross, Ga., has been appointed superintendent of shops at Waycross, succeeding D. M. Pearsall, whose appointment as superintendent of motive power has already been noted in these columns.

J. E. BURKE has been appointed roundhouse foreman of the Kansas City Southern at Pittsburg, Kans. He was formerly roundhouse foreman of the Chicago & Alton at Bloomington, Ill., resigning from that position in March, 1919.

W. J. SKELTON, roundhouse foreman of the Missouri, Kansas & Texas at Denison, Texas, has been appointed general foreman there, succeeding B. C. Nicholson.

OBITUARY

WILLIAM T. GORRELL, formerly master car builder of the Philadelphia & Reading at Reading, Pa., died December 13, 1919, at his home in Reading. Mr. Gorrell was born near Aberdeen, Md., on January 23, 1844. He was taught cabinet making by his father and then entered railroad work as a car builder in 1869 on the Central Ohio at Bellair, Ohio, later working at his trade on the Cleveland & Pittsburgh at Wellsville, Ohio, and the Pittsburgh, Cincinnati, Chicago & St. Louis at Dennison, Ohio. On April 15, 1873, he began work with the Philadelphia & Reading at the Reading car shop and was successively foreman of the passenger car department, general foreman and assistant master car builder, and on March 1, 1897, was appointed master car builder, which position he held until he was retired and pensioned when he reached the age of 70, on February 1, 1914.

SUPPLY TRADE NOTES

The Streator Car Company, Streator, Ill., is building a new plant at Kankakee, Ill., which will be devoted to the building of steel cars.

The Railway Motor Car Company, Hammond, Ind., contemplates the erection of a power plant and machine shop at its plant to cost approximately $200,000.

Arthur Haller, of the New York office of the American Locomotive Company, has been promoted into the company's sales department, with headquarters at Chicago.

The Union Tank Car Company announces that it has acquired 120 acres of land in Lima, Ohio, with the intention of erecting car shops in the future on the site.

Willis E. Martin, treasurer of the H. K. Porter Company, Pittsburgh, Pa., died on January 12, after a prolonged illness. Mr. Martin had been connected with this company for 44 years.

H. P. Wingert has resigned his position as general purchasing agent of the American Brake Shoe & Foundry Company to become the president of the American Commodities Company with offices at 30 Church street, New York. This company is engaged in the handling of fuel and foundry supplies and railway materials. Mr. Wingert is well known in railway circles. Beginning his business life as a messenger boy, he became a telegraph operator and later held positions of responsibility with the Pennsylvania Railroad, the New York Central and the Central Railroad of New Jersey. He resigned as assistant to the purchasing agent of the Central Railroad of New Jersey to become purchasing agent of the American Brake Shoe & Foundry Company at the time of its organization.

H. P. Wingert

The Air Brake Safety Appliance Company has been incorporated at Indianapolis, Ind., with a capital of $10,000 for the manufacture of a safety device to be used in connection with air brakes.

A. H. Hawkinson, assistant manager of the Garratt-Callahan Company, has been appointed sales manager with jurisdiction over the railroad and industrial departments, succeeding E. V. Sackett.

C. M. Rogers has resigned as supervisor of stationary plants on the Chicago, Rock Island & Pacific, with office at Chicago, to become manager of service of the Locomotive Fire Box Company, Chicago, with headquarters at 630 Marquette building.

C. C. Humberstone has been appointed Chicago sales manager of the Anchor Packing Company, Philadelphia, Pa., under the jurisdiction of J. T. Landreth, western sales manager, with headquarters at Chicago. Mr. Humberstone was formerly with the engineering department of the Pennsylvania.

The Duff Jack Sales Company, Ltd., located at 245 Oxford street, London, England, has been formed to represent the Duff Manufacturing Company of Pittsburgh in the British Isles, and has been given the exclusive agency in this territory for Duff and Barrett jacks.

The Chicago Flexible Shaft Company, Chicago, has opened a New York office at 350 Broadway, for the distribution and sale of furnaces, forges and heat treating equipment. The office will be in charge of J. W. Lazear, formerly with the Brown Instrument Company, Chicago.

I. F. Baker, of the Westinghouse Electric International Company, who has been located in the New York office of that company for the past two years, is now on his way to Tokio, Japan, where he will act as a special representative of the Westinghouse International Company.

A. S. Winter has resigned as advertising manager of the William Powell Company, Cincinnati, Ohio, to become connected with the sales force of the Fairbanks Company, New York, and will represent this company in Southern Ohio territory. Mr. Winter will have his headquarters at the Pittsburgh office of the company.

A. R. Horn, who served for over ten years as inspector of devices of the Q & C Company, New York, in connection with its Chicago office, died at Minneapolis, Minn., on December 28, 1919, at the age of 70. Before his connection with the Q & C Company Mr. Horn was division superintendent of the Wisconsin Central Railroad.

Evarts S. Barnum of the G. M. Basford Company, New York, died at his home in Ridgewood, N. J., on February 3, of pneumonia, after an illness of eight days. Mr. Barnum was born in Louisville, Ky., in 1883 and received his education at Purdue University, from which he graduated in 1906. His entire business life was connected with railroad work. Immediately upon his graduation from the University, he entered the service of the Pennsylvania Lines West as apprentice and worked successively as apprentice, machinist, foreman, general foreman, roundhouse foreman and motive power inspector. Leaving the railroad in 1917 he joined the editorial staff of the Simmons-Boardman Publishing Company as an associate editor of the Railway Age and the *Railway Mechanical Engineer* and later became associated with the G. M. Basford Company and was in charge of the copy department of that company.

E. S. Barnum

The Wm. Graver Tank Works, Chicago, announces that it has changed its name to the Graver Corporation. There is no change in the management, ownership or directorate.

C. H. Beck, special representative of the Safety Car Devices Company at Pittsburgh, Pa., succeeds C. R. Ellicott as assistant eastern manager at New York.

Errett V. Sackett, who has been manager of the railroad department of the Garratt-Callahan Company for the past five years, has resigned to accept a position as assistant to the president of the Seller Distributing Company, Detroit, Mich., taking charge of sales. This company is the foreign distributer for a large number of American companies. Mr. Sackett left for Europe early in January to study conditions in England and the Continent, to return about May 1.

C. P. Patrick, vice-president of the Master Boiler Makers' Association, and general boiler inspector on the Erie, has been appointed general manager of the Chicago Wilson Welding & Repair Company, with headquarters at Chicago, succeeding E. S. Fitzsimmons, who has resigned to become assistant sales manager of the Flannery Bolt Company, Pittsburgh, Pa.

Arthur A. Frank, in charge of the western territory of the Standard Railway Equipment Company, New Kensington, Pa., with office at Chicago, has been elected president of the company. Mr. Frank was born at St. Louis, Mo. For a number of years he was connected with the transportation and mechanical departments of the Missouri Pacific. In 1911 he entered the supply trade field as secretary to the president of the T. H. Murphy Company, New Kensington, Pa., and later was promoted to the position of factory manager. In 1914 he was appointed sales agent of the Standard Railway Equipment Company in charge of the southwestern territory, with office in St. Louis, Mo. In July, 1918, he was transferred to Chicago, in charge of the entire western territory, which position he retained until his recent election as president. In addition to the presidency of the Standard Railway Equipment Company he will retain his office as vice-president of the Pressed Steel Manufacturing Company, the Imperial Appliance Company and the Union Metal Products Company.

A. A. Frank

The Cleveland office of B. M. Jones & Co., Inc., New York, selling agents for Mushet steels and Taylor iron, has been moved from 824 Engineers building to 115 St. Clair avenue, N. W., where the office and warehouse have been combined. Walter E. Sargent, formerly of Detroit, Mich., is now connected with the New York sales office of the company at 192 Chambers street.

The Locomotive Export Association of New York City has filed papers with the Federal Trade Commission in accordance with the provisions of the Webb-Pomerene Act setting forth the details regarding its organization to export locomotives and parts thereof. The stockholders include the Baldwin Locomotive Works, the American Locomotive Company and the Montreal Locomotive Works.

The Vanadium Corporation of America, 120 Broadway, New York, has bought all of the properties, excepting cash, receivables and securities, of the Primos Chemical Company, the Primos Exploration Company, and the Primos Mining & Milling Company, producers of vanadium, molybdenum, tungsten and other steel alloys, and having valuable deposits of these elements in Colorado, and a large refining plant at Primos, near Philadelphia, Pa.

The Norton Company, Worcester, Mass., has under construction a new plant at Hamilton, Ont., for the complete manufacture of Norton wheels. The manager of the new plant is R. C. Douglas, formerly a representative of the com-

pany in upper New York state and Ontario. Mr. Douglas will be assisted in his work of organization by several foremen from the Worcester plant. It is expected that the Hamilton plant will be completed, ready for operation, by April or May.

Arthur E. Blackwood, manager of the New York office of the Sullivan Machinery Company, Chicago, has been promoted to vice-president in charge of finance and accounting, with headquarters at Chicago. Louis R. Chadwick, manager of the company's office at Spokane, Wash., has been transferred to the New York office, succeeding Mr. Blackwood. Robert T. Banks, sales engineer, with office at El Paso, Tex., has been promoted to manager of the Spokane office, succeeding Mr. Chadwick.

Joseph Robinson, the inventor of the Robinson connector and formerly president of the Robinson Connector Company, has again become associated with the company. This follows an absence from the company of two years during which time Mr. Robinson has had no managerial or mechanical association with it. In his new association he will act in an advisory capacity, working in co-operation with A. R. Whaley, vice-president of the company and formerly vice-president of the New York, New Haven & Hartford Railroad. Mr. Robinson was born in Dayton, Wash., on July 21, 1889. His family later went east to Illinois where, after leaving school at the age of 12, he worked on a farm until he was 14. He then went west again and worked in a blacksmith shop until the age of 18 when he opened an office at Salem, Ore., as a designer of special machinery. While doing this work his attention was drawn to the need of a better means of coupling hose on railway trains. He worked out the design of the Robinson connector for this purpose and after a study of the problem he came east with the device in 1909 and in 1910 organized the Robinson Connector Company of which he became president. For the next eight years he devoted his efforts to the development of the business represented by the company, until 1918, when he turned his interest over to other hands who, since that time, have been developing the device, Mr. Robinson retaining only the ownership of the patents, but no other connection than lessor with the company, until his return to it as noted above.

Jos. Robinson

The Conradson Machine Tool Company, Green Bay, Wis., has been incorporated recently with C. M. Conradson, at one time associated with the Gisholt Machine Company and later engaged in general consulting work in tool design, as president. The products of the new concern, consisting of milling machines, lathes, planers and radial drills will be marketed by Joseph T. Ryerson & Son. Work was begun on the Conradson plant in the spring of 1918 and was completed recently. Equipment is installed and production now under way.

The Kearney & Trecker Company, Milwaukee, Wis., announces that since February 1, 1920, the Cleveland, Ohio, office and warehouse of the company has been located at 738 Superior avenue, N. W., where larger quarters are occupied and where a line of Milwaukee milling machines, attachments and accessories will be carried. C. J. Sturgeon, formerly with the W. M. Pattison Supply Company, Cleveland, will be in charge of sales in the Ohio territory, succeeding C. C. Bauschke, who has resigned to engage in business on his own account.

The Westinghouse Air Brake Company, Pittsburgh, Pa., has created an export department to provide facilities adequate to handle the increasing export business and to develop its foreign trade to a greater extent than has been heretofore possible, with headquarters in the Westinghouse building, Pittsburgh, Pa. E. A. Craig, who has been appointed manager of the export department, has been associated with the Westinghouse Air Brake Company for 32 years. The new department will be represented in the New York office by W. G. Kaylor, and in South America by R. M. Oates.

Lester W. Collins has been appointed chief engineer of the Refrigerator Heater & Ventilator Car Company, with offices in the Merchants National Bank building, St. Paul, Minn. During the war emergency, Mr. Collins was connected with the United States Department of Agriculture as refrigeration technologist in charge of the development of a standard heater car for the protection of perishable lading in transit, for the refrigerator car committee appointed by the United States Railroad Administration. For seven years previous to his government service, he was an assistant to H. B. MacFarland, engineer of tests of the Santa Fe, and he was in charge of the special transcontinental tests made for the Santa Fe Refrigerator Despatch Company, on California fruits and vegetables handled in this company's equipment.

Kingman Brewster, until recently associated with the Greenfield Tap & Die Corporation, has been appointed president of the Millers Falls Company, Millers Falls, Mass. Born in Worthington, Mass., in 1882, Mr. Brewster was educated in the public schools of that town, Williston Seminary, Amherst College and Harvard Law School. He graduated from the latter in 1911 and in the same year was admitted to the bar in Oregon, practicing law there until 1914. He returned east to practice law in Massachusetts and in 1917 served as registrar and counsel of the Federal Land Bank of the First District; also counsel for the Besse System stores and other corporations. In 1918 Mr. Brewster became vice-president and general sales manager of the Greenfield Tap & Die Corporation. Mr. Brewster has recently been appointed to his new position as president of the Millers Falls Company.

Kingman Brewster

The Falls Hollow Staybolt Company, Cuyahoga Falls Ohio, announces the appointment of the following sales representatives: Charles Hubbard & Co., 81 Fulton street, New York; Warren Corning & Co., Transportation building, Chicago; Certes Supply Company, Frisco building, St. Louis, Mo.; Spalding & Small, 1010 Hurt building, Atlanta, Ga.; Read-Rittenhouse Company, 1234 Commercial Trust building, Philadelphia, Pa.; Berger-Carter Company, Tenth and Mississippi streets, San Francisco, Cal.; A. M. Castle & Co. of Washington, Seattle, Wash.; and Austin & Doten, 102 North street, Boston, Mass.

The Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., has announced the following promotions among its officers at East Pittsburgh: Alexander Taylor, for many years manager of works, has been made assistant to vice-president in general charge in all plants of production, stocks and stores. R. L. Wilson, general superintendent, has been promoted to works manager of the East Pittsburgh works. E. R. Norris has been appointed director of works equipment in charge of machinery, tools and methods in the various plants. Other appointments include: G. M. Eaton, chief mechanical engineer of the company; C. W. Johnson and H. W. Cope, assistant directors of engineering; C. H. Champlain and E. S. McClelland, assistant works managers; F. E. Wynne, manager of the railway equipment engineering department; and G. H. Garcelon, manager of the small motor engineering department.

A. N. Lucas, superintendent of the locomotive shop of the Chicago, Milwaukee & St. Paul, at Milwaukee, Wis., left the service of the railroad February 1 to become district manager of the Oxweld Railroad Service Company, with headquarters at Chicago. Mr. Lucas was educated in the public schools of Green Bay, Wis., and entered railway service at that point as a boilermaker apprentice. Late in 1881 he went to the Chicago & North Western shops at Escanaba, Mich. He remained there until January, 1883, and then returned to Green Bay, Wis., to enter the service of the Milwaukee Northern, now part of the Chicago, Milwaukee & St. Paul System. Here he was subsequently appointed boilermaker foreman. In January, 1901, he was transferred to Dubuque, Iowa, in charge of the boiler shop, remaining there until April, 1904, when he was transferred to the Milwaukee shops. Soon after this he was advanced to the position of general foreman of boiler work for the entire system. In May, 1917, he was promoted to the position of assistant superintendent motive power and a year later was placed in charge of the locomotive department of the Milwaukee shops as shop superintendent. Mr. Lucas is a past president of the Master Boilermakers' Association and is at the present time a member of the executive board of that organization.


A. N. Lucas

The Barco Manufacturing Company, Chicago, has increased its capital stock to $500,000 and contemplates building a new factory to accommodate the manufacture of several new devices which it expects to put on the market in the near future.

The Pollak Steel Company, Cincinnati, Ohio, manufacturers of railroad car axles, locomotive forgings and heavy forgings for marine and machine builders, with plants at Cincinnati and South Chicago, Ill., announces that it has recently added to its South Chicago plant a large extension for the manufacture of drop forgings for the automobile, tractor and agricultural implement trade and has added to its Cincinnati plant a large extension for the manufacture of automobile parts. The Pollak Steel Company has also just closed negotiations with the Interstate Iron & Steel Company, Chicago, for the purchase of its rolling mill property at Marion, Ohio. In addition to its manufacture of specialties, such as automobile parts and drop forgings, which cannot be measured on a tonnage basis, this now gives the Pollak company a capacity of both forged and rolled products of approximately 300,000 tons a year.

S. F. Bowser & Company, Inc., have extensive plans under consideration for expansion during the present year. The company plans the erection of a warehouse and office building at Dallas, Tex., and the organization of a subsidiary corporation to be known as S. F. Bowser & Company of Texas, for the sale of the Bowser products throughout that state and adjacent territory. E. P. Murray, formerly assistant general sales manager, with headquarters at Chicago, will assume the management of the new company at Dallas. During the war the company closed its branch offices at Denver, Colo., Memphis, Tenn., and St. Louis, Mo. These offices will be re-established, A. S. Bowser, assistant to the treasurer, with headquarters at Fort Wayne, Ind., having been appointed manager of the Denver office; B. L. Prince, who has been district manager of the Dallas office, has been transferred to the Memphis office, and Willard D. Smith, connected with the sales department, has been appointed manager of the St. Louis office. A new district office will be established at Detroit, Mich., and L. E. Porter, assistant district manager at Fort Wayne, Ind., has been appointed district manager of the new Detroit office.

National Steel Car Company Changes Hands

Robert J. Magor and associates have bought the plant and property, and taken over the assets and liabilities of the National Steel Car Company, of Hamilton, Canada, and will continue the business under the name of the National Steel Car Corporation. The plans of the new corporation are to substantially increase its freight car manufacturing facilities and also develop on a large scale the motor truck business, which in the old company was only carried on in a very small way.


R. J. Magor

Mr. Magor, who is president of the Magor Car Corporation, New York, engaged in the car building business, has been elected president also of the new corporation. He was born on July 6, 1882, at Montreal, Canada, was educated in high schools and also received private tuition. In November, 1905, he entered the car building business with the Canadian Car & Foundry Company and in June, 1910, left the service of that company to take over the management of the re-organized Magor Car Company plant at Passaic, N. J. Since Mr. Magor took over the management of this plant the production has been increased ten times, and extensions are now being made, to be completed in the early spring, that will double the present capacity of the plant. In 1912 Mr. Magor assisted in designing the plant of the National Steel Car Company, Hamilton, Canada, and two years later was elected to the board. In the early part of 1919 he was made consulting vice-president, and as the company sustained large losses on a French war contract it was necessary to reorganize it, additional capital being put in. This was done by submitting to the company a proposition of purchase, which was accepted, and on December 18, 1919, the purchase was completed and Mr. Magor elected president of the National Steel Car Corporation, Ltd.